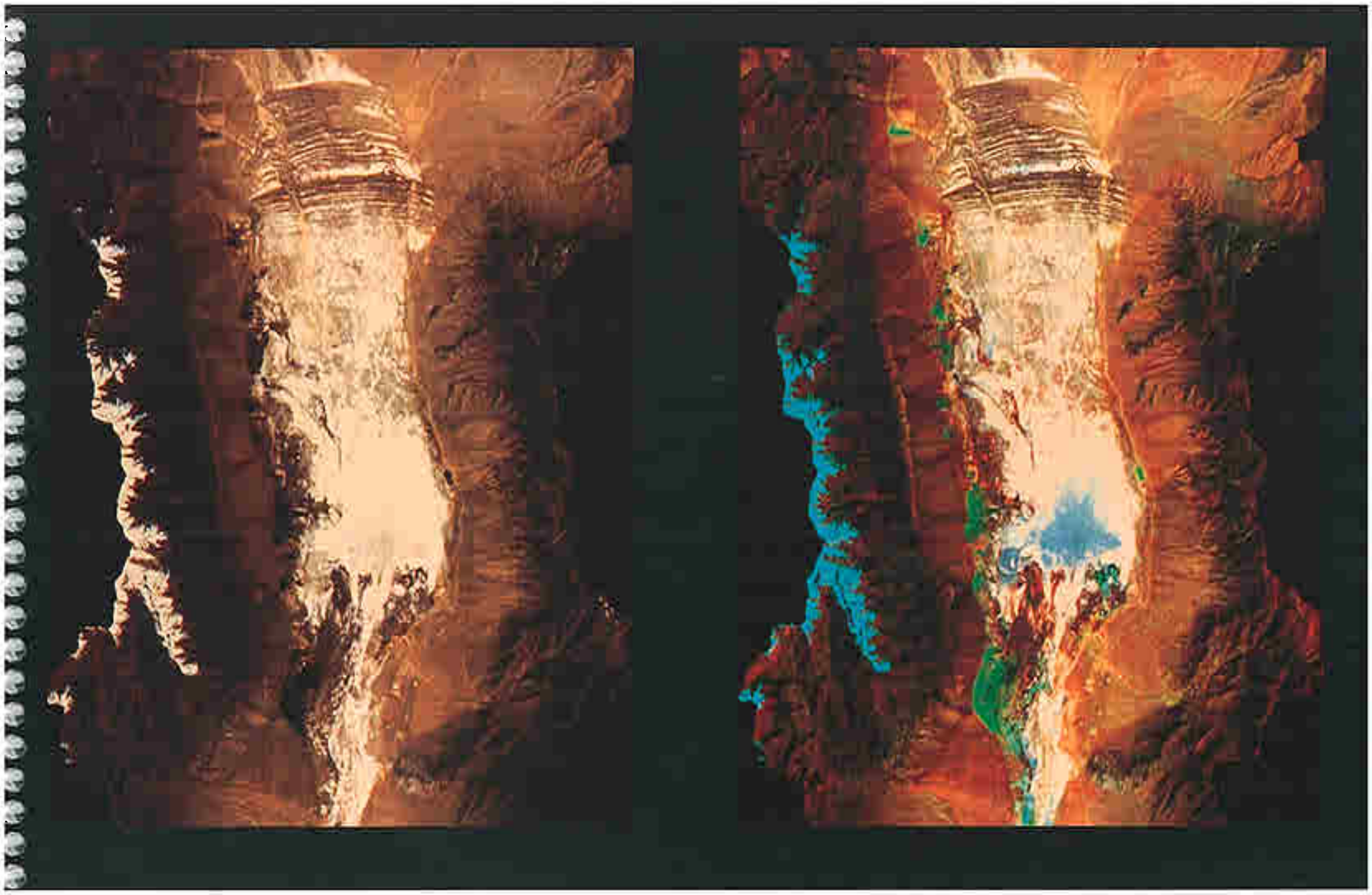

HYDROLOGY AND STEADY STATE GROUND-WATER MODEL OF SPRING VALLEY, LINCOLN AND WHITE PINE COUNTIES, NEVADA

1994

Las Vegas Valley Water District

COOPERATIVE WATER PROJECT
Water for Nevada's Future
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Hydrographic Basin 184

HYDROLOGY AND STEADY STATE GROUND-WATER MODEL OF SPRING VALLEY, WHITE PINE AND LINCOLN COUNTIES, NEVADA

By

Kay Brothers and Alan J. Bernholtz, Las Vegas Valley Water District

and

Thomas S. Buqo and James V. Tracy, Ph.D., Consulting Hydrologists

1994

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PREFACE

This report on the water resources and development potential of Spring Valley is one of a series of reports on hydrographic basins in eastern and southern Nevada, prepared by the Las Vegas Valley Water District as part of the District's Cooperative Water Project. Kay Brothers and James V. Tracy developed the ground-water flow model and co-authored the report. Thomas S. Buqo performed detailed evaluations of the available data and prepared selected portions of the report. Alan J. Bernholtz performed water quality sampling and prepared the chemistry section. Chiuwen Ray prepared all the report figures. Richard Barrett performed the satellite imagery analysis to arrive at irrigated acreages. Information used in performing this work was provided by the Nevada State Engineer's office, the U.S. Geological Survey, Summit Engineering, Inc., and the U.S. Air Force. Additional information and technical assistance was provided by the staff of the Research Department of the Las Vegas Valley Water District, under the direction of Terry Katzer, Director.

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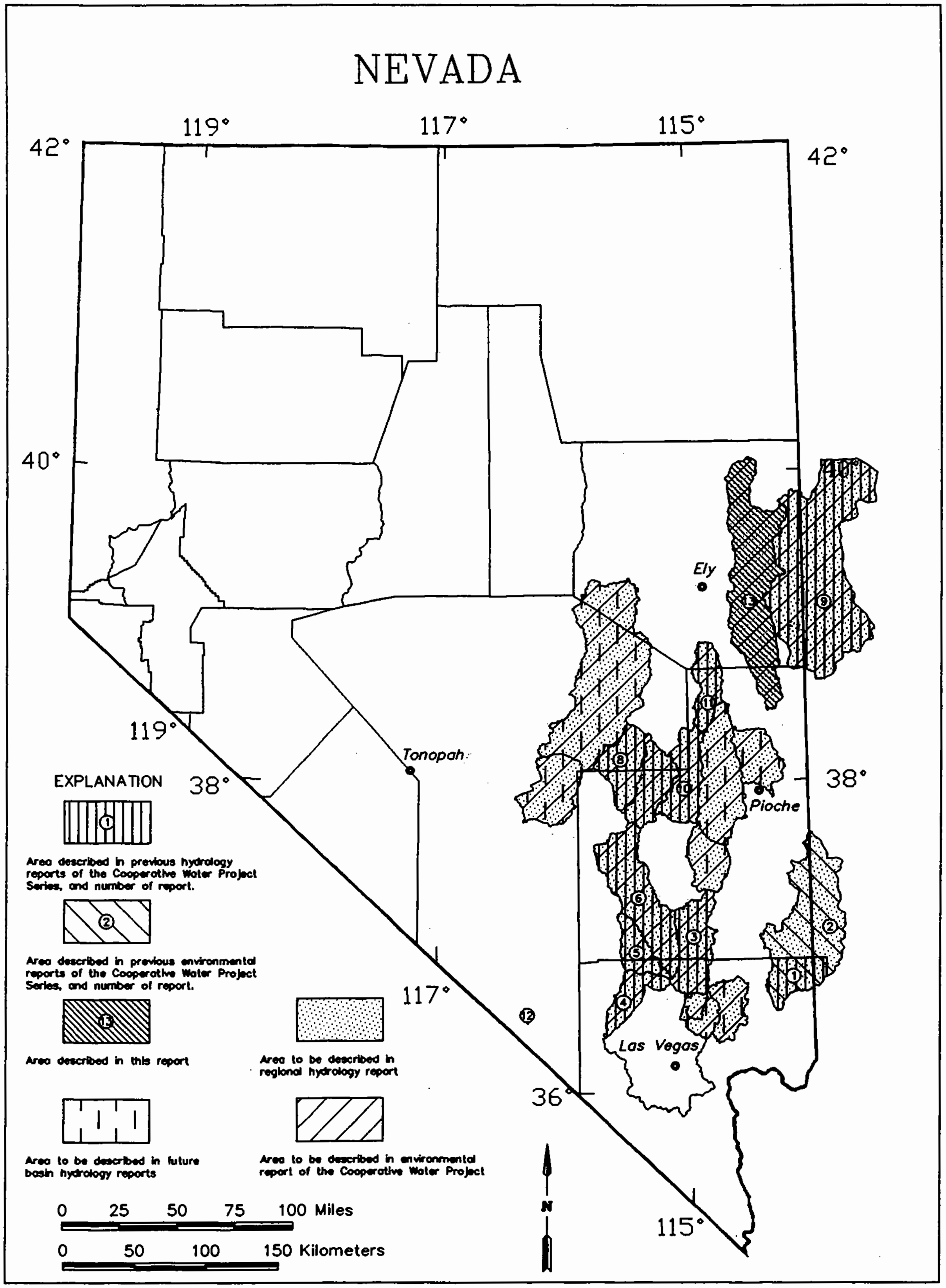


Areas described in previous reports of this series, the area described in this report and the areas to be described in future reports.

INTRODUCTION

In October 1989, the Las Vegas Valley Water District (District) filed nineteen applications to obtain ground-water rights from Spring Valley in White Pine and Lincoln Counties, Nevada. Since the time of these water right filings, the District has conducted extensive investigations of Spring Valley and adjacent areas including the collection of basic hydrologic data, a water rights inventory, the synthesis of all published and agency information on the water resources of the area, and the development of conceptual and numerical models of the valleys. This report details the hydrologic assessments of Spring Valley that were conducted, and the steady-state ground-water flow model developed to represent the aquifer systems of the basin.

Background

Spring Valley is a large basin located about 300 miles north of Las Vegas, Nevada (Figure 1). Most of Spring Valley is situated in White Pine County; however, the southernmost portion is located in northern Lincoln County. More than 120 production, test, and observation wells have been drilled in the valley; data concerning these wells provides much information about the alluvial aquifer. On the basis of the geology of the basin, the hydrogeology of neighboring basins and limited test drilling performed as part of the U.S. Air Force's MX Missile water resources program, it is known that the regional carbonate aquifer underlies Spring Valley.

To assist its efforts in understanding the water resources of Spring Valley, the District developed a numerical model of the ground-water flow regime of the basin. A numerical model is a computer code which translates the mechanics of ground-water flow through the earth through a series of mathematical equations. By coupling the available information on the basin (and similar valleys in Nevada) with the predictive capabilities of the model, it is possible to estimate the response of the ground water to the proposed water withdrawals by the District.

The development of a ground-water flow model for Spring Valley serves two important purposes. First, it is a useful planning tool in developing well field designs by allowing water supply design experts to simulate the efficiency of different design alternatives; secondly, it allows planners to simulate the potential effects of the water withdrawals, if any, on neighboring water users, and the environment.

Both beneficial and negative impacts may result from ground-water withdrawals from the valley-fill deposits and/or the regional carbonate aquifer in the arid basins of Nevada. The benefits derived from the application of currently unused ground-water to beneficial use is, of course, the primary positive impact. The economic impact of large-scale ground-water development programs, such as that proposed by the District, is likely to be appreciable and the project is likely to result in significant short-term and long-term economic benefits. The proposed program will require the cooperative efforts of large teams of scientists, engineers, and water planners, and the services of the water well and construction industries.

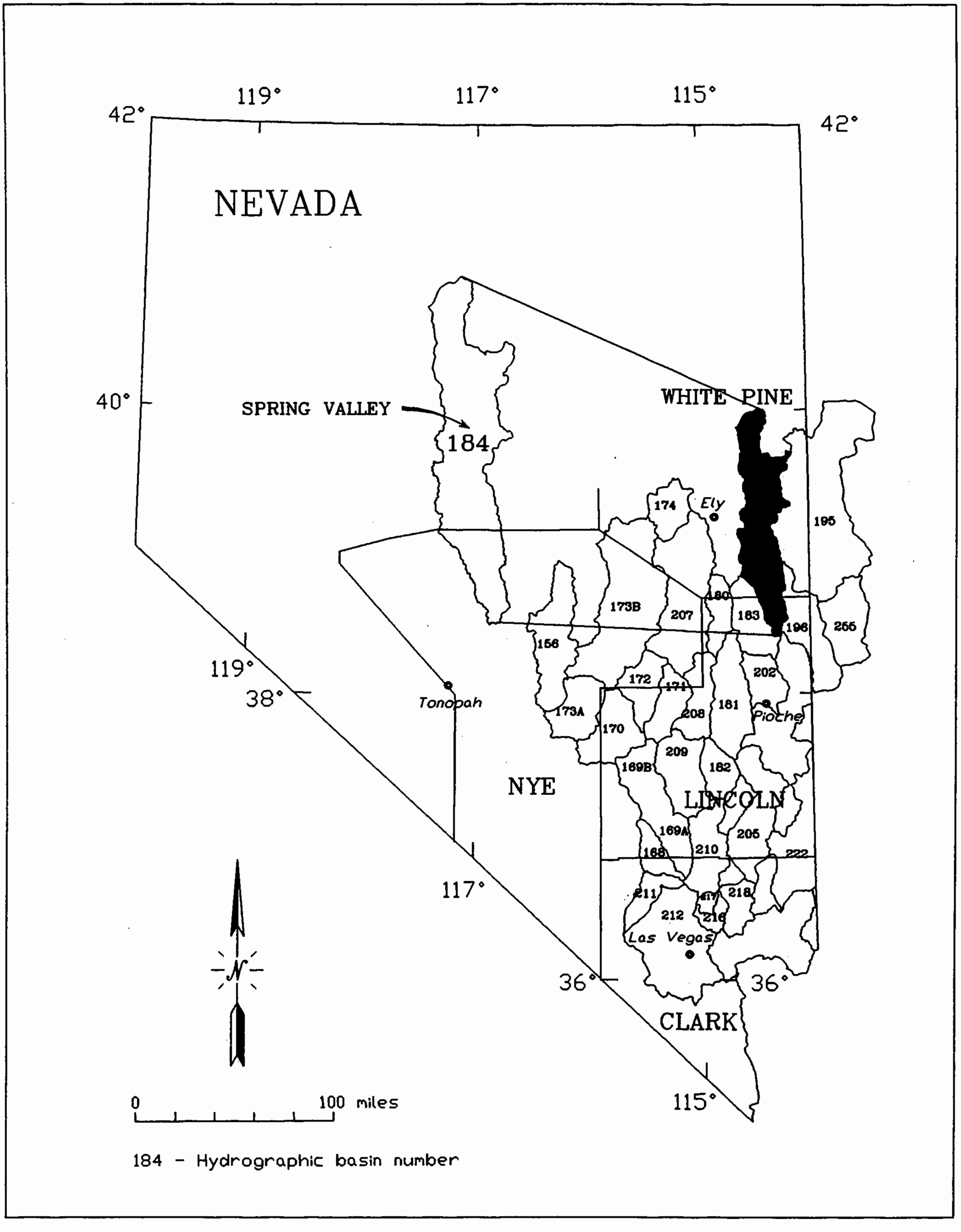


Figure 1. -- Location of the study area

Beside the favorable economic impacts expected to result from the proposed development of ground water in Spring Valley, negative impacts can occur. The primary negative impact of ground-water withdrawals is the lowering of ground-water levels in the vicinity of the production wells; this lowering of water levels is commonly referred to as drawdown. If the long-term drawdown near a pumping well, or a wellfield in any given valley, is significant, then the direction and rate of ground-water flow can be altered and potentially may result in:

- Increased pumping lifts and costs;
- Reductions in spring-flow rates;
- Reductions in surface-water flows; and
- Degradation of water quality.

The magnitude and significance of these impacts depends largely upon the overall hydrologic setting of the basin where the withdrawals occur. In remote, undeveloped basins with no surface water or large springs, the drawdown that will result from ground-water development may not result in significant adverse impacts within the valley. In other instances, the presence of sensitive environments in a valley may be adversely impacted as a result of the same amount of drawdown. Examples of sensitive environments in Nevada include: 1) wetland areas that provide valuable habitat for many types of wildlife; 2) surface water flows and their associated riparian habitats; 3) springs that either support wildlife or have been developed for ranching, mining, quasi-municipal, or domestic uses; and 4) areas where ground water provides the sole source of drinking water for a community.

There are large areas of Spring Valley that contain seasonal wetlands. These areas receive a large amount of runoff from the snow melt over the Schell Creek and Snake ranges. This water ponds in the lowland areas and supports extensive stands of plants, primarily greasewood, saltgrass, and rabbitbrush. Although none of the springs in Spring Valley have been classified as regional, there are hundreds of individual springs and seeps. The USGS has mapped the locations of seven springs with discharge rates of more than 1000 gallons per minute (slightly more than 3 cfs). There are no wildlife management areas in the basin; a portion of Great Basin National Park is in Spring Valley in the upland areas of the Snake Range south of U.S. Highway 50.

Because many of the valleys in central, eastern, and southern Nevada are hydraulically linked, via the regional carbonate aquifer, the drawdown that results from the development of ground water in one valley can impact the environment of another valley. Thus, the development of a numerical model of ground-water flow to simulate the impacts of pumping must take into account the environment in peripheral valleys as well as the valley actually being modelled. The District is in the process of preparing a computer model to evaluate these potential regional impacts.

Spring Valley is potentially in hydraulic communication with Tippett Valley to the north and is in direct communication with Hamlin Valley to the south. Along with several basins in western Utah, these valleys comprise a large regional flow system known as the Great Salt Lake Desert

Flow System (Harrill, et al., 1988). Withdrawing water from Spring Valley could potentially have effects on downgradient basins and any ground-water development will be monitored.

The use of numerical methods to simulate water withdrawals in Spring Valley provides a tool for predicting the effects that would be expected to result from potential development. Recently, the U.S. Geological Survey (USGS) has reported the findings of a cooperative study of the water resources potential of the carbonate aquifer conducted in cooperation with the U.S. Bureau of Reclamation, state and local agencies, including the District (Dettinger, 1989). This report recommends the effective use of computer models for predicting the site-specific effects of water withdrawals from the carbonate aquifer. The report concluded that increased confidence in such predictions can be achieved through a staged approach to development coupled with adequate monitoring and interpretation. The development of a computer model of the steady-state ground-water flow regime in Spring Valley, performed as part of this investigation, represents one of the first steps in implementing such a staged approach.

The steady-state ground-water model, described in this report, provides a preliminary representation of the aquifer system based upon the information available at this time. As additional data become available through District efforts, the model of the ground-water flow regime for Spring Valley can be updated accordingly to provide a more refined representation of the hydrologic system.

Purpose and Scope

The purpose of this project is twofold: 1) to define the hydrologic conditions of Spring Valley, and 2) to develop a calibrated steady-state ground-water flow model of the valley. The specific objectives of these investigations were to:

- Collect land use data in the valleys;
- Compile and review published reports and unpublished data on the valley;
- Interpret the available data and determine the characteristics of the valley; and
- Prepare a computer model to simulate steady-state ground-water flow in the valley.

To achieve these objectives, a detailed investigation of the hydrologic conditions of Spring Valley was conducted. The scope of work included a review of all available published and unpublished data, the evaluation of the occurrence and movement of ground water and water chemistry, and the development of conceptual and steady-state numerical models of the hydrogeologic regime of the valley. The basin characterization information and steady-state flow model discussed in this report will be used by the District to develop a transient, regional model including the Spring Valley ground-water regime.

Location and Physiographic Setting

Spring Valley is within the Great Basin Physiographic Region as defined by Fenneman (1931). The location of the valley and its general physiographic setting are shown in Figure 2 and 2A are discussed below.

Spring Valley is located between the Schell Creek Range on the west, the Kern Mountains, Red Hills and Antelope Range on the north and northeast, the Snake Range on the east, and the Fortification Range, Limestone Hills, and Wilson Creek Range on the south. The basin is topographically closed i.e., there is no surface water drainage out of the basin. To the north, the Spring Valley ground-water regime may be in direct hydraulic communication with Tippett Valley as hypothesized by Rush et al. (1971) and Harrill et al. (1988). Along its southeastern boundary (in the Limestone Hills area), the ground water of Spring Valley is in direct hydraulic communication with Hamlin and Snake Valleys.

Spring Valley is approximately 115 miles along its central axis, a maximum of 25 miles wide, and covers 1,661 square miles (Scott, et al., 1971). The valley floor averages about 5,700 feet above mean sea level (AMSL) and ranges in elevation from more than 6500 feet AMSL high on the alluvial fans to about 5,550 feet AMSL at Yelland Dry Lake. A depression occurs in the north-central part of the basin from the Red Hills to south of Yelland Dry Lake.

On the northeast Spring Valley is bounded by the Antelope Range, which rise generally to elevations over 8,200 feet AMSL with a maximum of about 9,380 feet AMSL at Baldy Peak. East of Becky Peak, between the northernmost part of the Schell Creek Range and Antelope Range, a high (7,200 ft AMSL) alluvial divide separates Spring Valley from Steptoe Valley. Southeast of the Antelope Range, Spring Valley is separated from Tippett Valley by another alluvial divide with an elevation of about 6,070 feet AMSL and the Red Hills, which rise to about 6,900 feet AMSL. Further to the south, the Kern Mountains have considerable area above 8000 feet AMSL with a maximum elevation of about 9,630 feet AMSL. Another alluvial divide separates Spring Valley from Snake Valley between the Kern Mountains and the Snake Range at an elevation of about 6,780 feet AMSL.

The east and west bounding Snake Range and Schell Creek Range are the dominate features bounding Spring Valley. On the east, the Snake Range rises to maximum elevations of 13,063 feet AMSL at Wheeler Peak and 12,050 feet AMSL at Mount Moriah. Similarly, on the west, Spring Valley is bounded by another high mountain massif, the Schell Creek Range, with maximum elevations of 11,883 feet AMSL at North Schell Peak and 11,765 feet AMSL at South Schell Peak with numerous lesser peaks of more than 10,000 feet AMSL.

On the southeast, a narrow topographic divide at Lake Valley Summit separates Spring Valley from Lake Valley. This divide, at about 6,150 feet AMSL, separates the Schell Creek Range from the Fortification Range. The peaks in the Fortification Range are lower, ranging from about 7,500 to 8,500 feet. On the extreme south, Spring Valley is bounded by the northern part of the Wilson Creek Range with maximum elevations of more than 7,800 feet AMSL at Atlanta Creek and Rosencrans Peak. Finally, on the extreme southeast, an alluvial divide and the

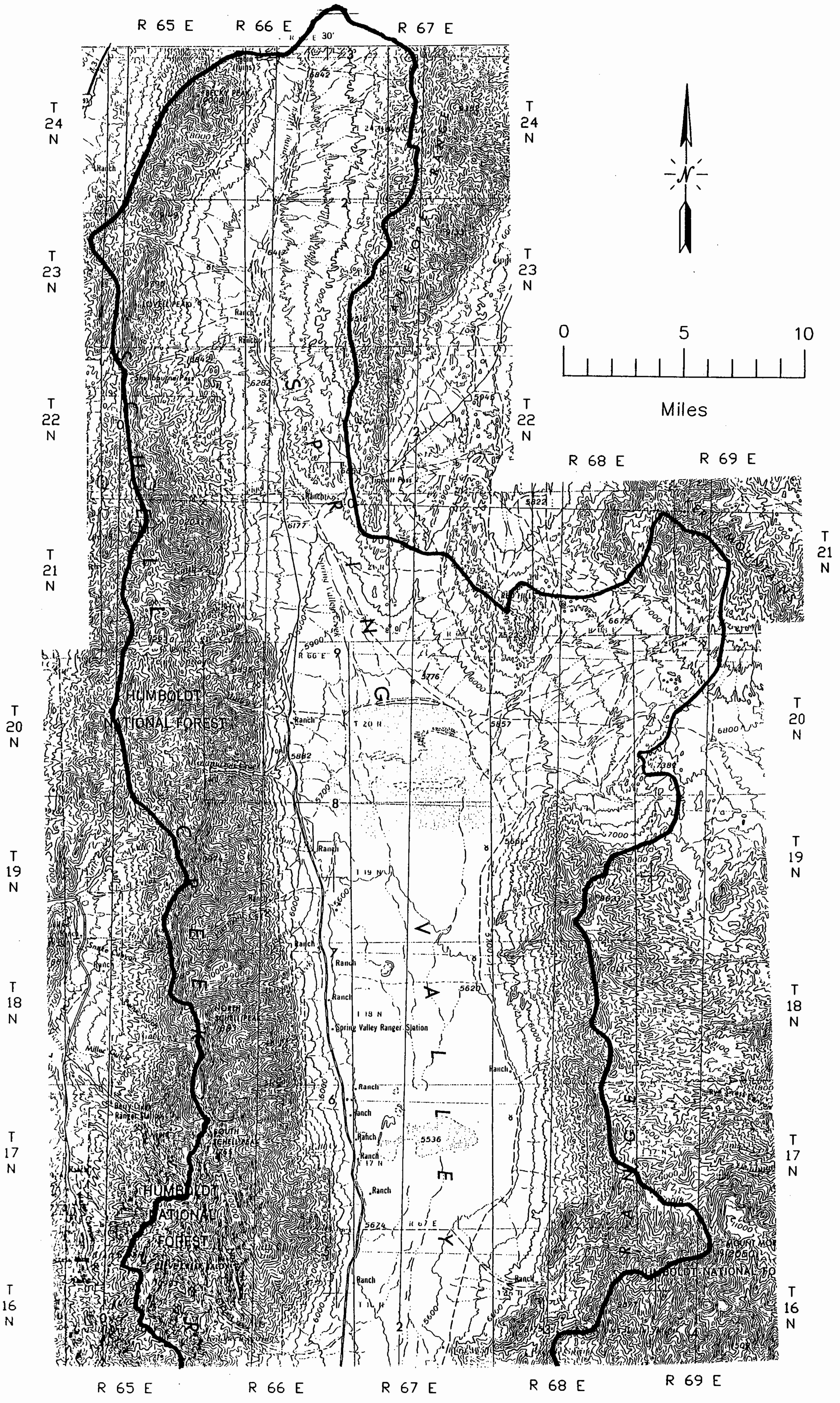


Figure 2. -- Physiography and location of Spring Valley (Northern Half).

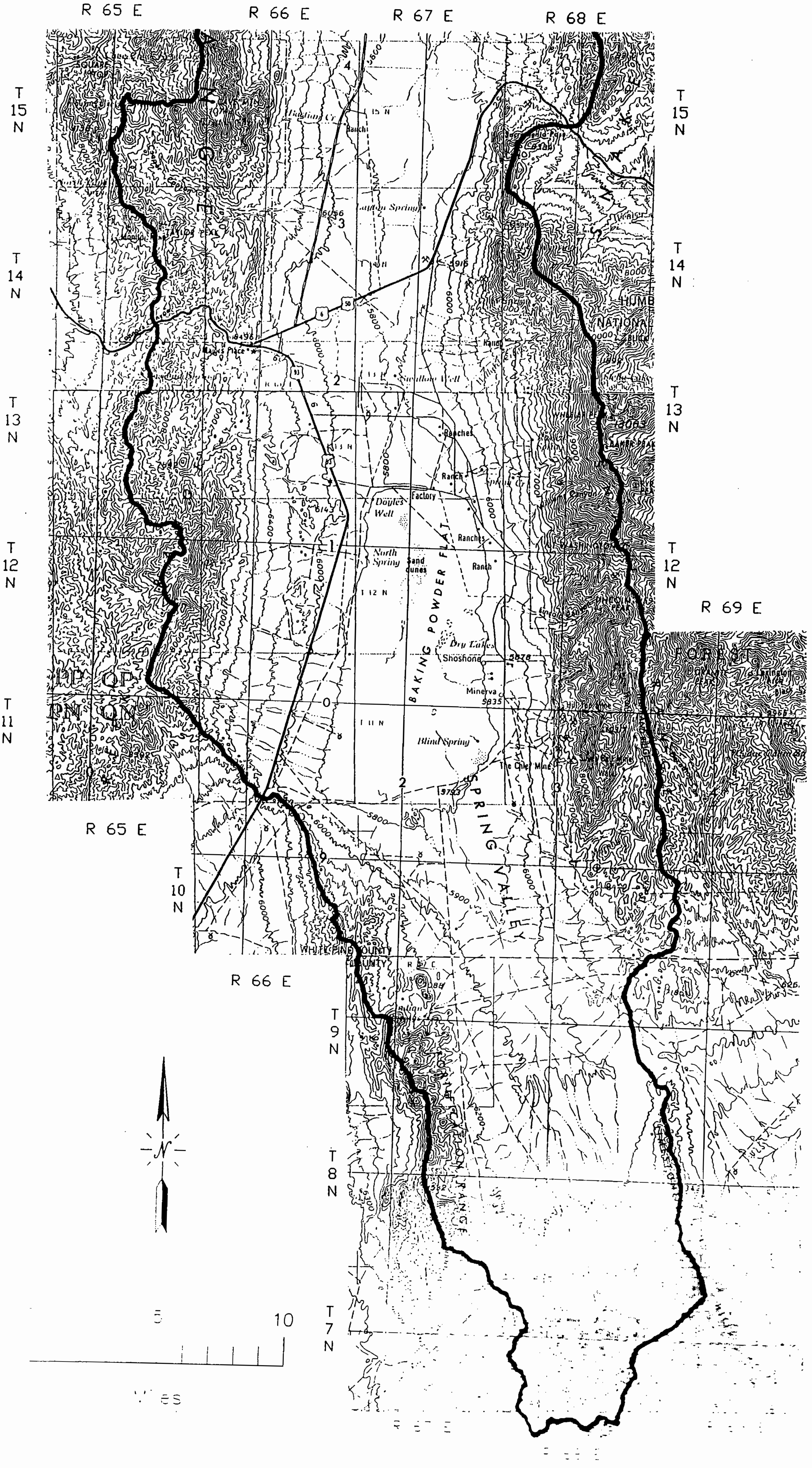


Figure [illegible] -- Physiography and location of Spring Valley [illegible]

Limestone Hills, with a maximum elevation of about 7,660 feet AMSL, separate Spring Valley from Snake Valley. The alluvial divide is in The Troughs area at an elevation of about 6,050 feet AMSL.

The physiography of Spring Valley is typical of other valleys in Nevada; mountains bound the valley on the east and west and alluvial fans radiate from the major mountain watersheds, forming a somewhat continuous bajada. On the valley floor, the major features are the numerous washes that drain the Snake Range and Schell Creek Range and the Pleistocene lake bed in the north-central part of the valley.

Availability of Data

Spring Valley are located in a remote and largely unpopulated portion of White Pine and Lincoln Counties, and only reconnaissance level evaluations of the water resources of the area are available. Records are available for more than 120 production, test, and observation wells that have been drilled in Spring Valley. Other available information includes published reports by the Nevada Bureau of Mines and Geology, the USGS, and the Desert Research Institute. In the late 1970s and early 1980s, the valley was also extensively investigated by the U.S. Air Force as part of their MX Water Resources Program. As a result of these previous investigations and the development that has occurred in the valley, the hydrologic conditions have been relatively well defined. Regional data from adjacent valleys are also available to supplement the existing valley-specific data.

The distribution of data points in the valley is quite good with no large areas lacking control. Table 1 provides summary data from the USGS data base and Bunch and Harrill (1984) for water level measurements in the valley for 59 wells. These wells were selected as representative of the overall ground water system on the basis of location and the date of the last water level measurement. Except for the northernmost part of Spring Valley, there are recent (1983 or later) water level data available for most of the valley floor area with older data available for wells located in upland areas.

Large scale maps (1:100,000 or larger) and small scale imagery also provide data useful in interpreting the hydrologic conditions of Spring Valley. Topographic maps of the basin show the locations of hundreds of individual springs. These springs provide additional information on ground-water elevations and movement, especially in the upland areas where wells are lacking. Remote sensing imagery is also available that allows evaluations of key ground-water indicators especially vegetation.

The valley-specific data was supplemented by regional data. Previous investigations in neighboring valleys have generated a data base of regional information which can be used to help formulate a ground-water model for Spring Valley. These data provide specific measures or estimates of the ground-water conditions at selected points in time and values for key hydrologic parameters. Several of the wells in adjacent valleys that were drilled as part of the Air Force's MX investigations extend through the valley-fill into the underlying carbonate rocks.

Table 1.--Selected water level data in Spring Valley, Nevada.

NEVADA					
ID NUMBER	LOCATION	LAND ELEV. (in ft. AMSL)	DEPTH TO WATER (in ft.)	WATER ELEV. (in ft.)	DATE MEASURED
1	8N-68E 23BAC1)	6180	418.5	5762	07/15/64
2	10N-67E 7BA	5800	84	5716	07/01/80
3	11N-66E 24BDA	5771	14	5757	03/08/90
4	11N-66E 1AAB	5790	2.5	5788	03/08/90
5	11N-66E 23AB	5840	46.77	5793	09/29/91
6	11N-66E 35DBA	57852)	2.52	5782	03/09/90
7	9N-68E 30AAA	5990	225.7	5765	03/08/90
8	10N-68E 31CD	5920	119.59	5800	09/28/91
9	11N-68E 19CDC	5920	94.83	5825	09/28/91
10	11N-68E 31CDC	5850	70.14	5780	03/08/90
11	10N-67E 16AAB	5825	40.1	5785	03/08/90
12	10N-67E 22AA	5920	65.58	5854	09/29/91
13	10N-67E 23ACB	5868	96.44	5772	03/08/90
14	10N-67E 26BB	5920	95.49	5825	09/29/91
15	11N-67E 13B	5800	7	5793	1935
16	17N-67E 28A	5560	22.1	5538	02/18/49
17	20N-67E 9BA1)	5780	182.5	5598	04/22/60
18	16N-67E 18A	5580	11.2	5569	08/15/49
19	18N-66E 1B	5600	20	5580	07/11/53
20	17N-68E 7AB	5560	19.82	5540	03/06/90
21	16N-67E 3AAA	5585	4.1	5581	03/07/90
22	16N-67E 27DAD	5600	7.7	5592	03/06/90
23	18N-67E 1CCA	5588	35.7	5552	03/06/90
24	19N-67E 13AAA	5620	46.37	5574	03/06/90
25	20N-67E 26ABB	5706	115.4	5591	03/06/90
26	12N-67E 8A	5750	20	5730	01/01/35
27	13N-67E 8ACA	5770	13.76	5756	07/03/90
28	13N-67E 31DDC	5792	29.2	5763	03/07/90
29	15N-66E 13D	5760	13.62	5746	12/06/91
30	16N-66E 36DBA	5860	215.68	5644	03/07/90

Table 1.--Selected water level data in Spring Valley, Nevada (Continued).

ID NUMBER	LOCATION	LAND ELEV. (in ft. AMSL)	DEPTH TO WATER (in ft.)	WATER ELEV. (in ft.)	DATE MEASURED
31	19N-66E 14AB	5700	43.04	5657	03/07/90
32	13N-67E 17DBA	5780	2.04	5778	04/20/83
33	13N-67E 18DCB	5850	51.03	5799	07/18/91
34	14N-66E 24AAB	5838	23.27	5815	03/06/90
35	14N-66E 24BDD	5840	35.94	5804	09/28/91
36	14N-66E 25BAD	5838	19.18	5819	03/06/90
37	15N-66E 25DAD	5840	31.44	5809	03/07/90
38	12N-67E 27B	5750	13	5737	10/13/55
39	14N-67E 22CCC	5790	56.6	5733	03/07/90
40	15N-67E 2DAC	5768[2]	150.44	5618	04/21/83
41	15N-67E 26CA	5680	35.04	5645	09/28/91
42	12N-67E 2ACB	5780	-21.3	5801	03/07/90
43	12N-67E 12CAA	5880	29.15	5851	03/07/90
44	12N-67E 13A	5900	8	5892	10/10/55
45	12N-67E 24BBB	5780	-11.4	5791	04/20/83
46	12N-67E 24CDD	5845	21.35	5824	03/08/90
47	13N-67E 15CBB	5860	83.64	5776	04/20/83
48	13N-67E 15CDA1	5880	103.37	5777	04/20/83
49	13N-67E 22ADB	5860	72.21	5788	04/20/83
50	13N-67E 26BAD	5860	72.82	5787	03/07/90
51	13N-67E 33DDA	5770	1.4	5769	04/19/83
52	13N-67E 34AAA	5810	2.25	5808	11/09/83
53	13N-66E 25A	5950	14.3	5936	09/27/60
54	21N-66E 4B	6076[2]	16.68	6059	04/21/83
55	23N-66E 19A	6400	20	6380	08/19/49
56	23N-66E 31AB	6400	19.98	6380	04/21/83
57	23N-65E 10D	6685	65	6620	04/22/60
58	23N-66E 7C	6480	15.8	6464	08/19/49

1) location changed from USGS data base to location found in USGS 1:100,000 map
2) elevation corrected based on USGS 7.5' quad

The primary source of data for Spring Valley is a reconnaissance report authored by Rush and Kazmi (1965). Investigators of the regional flow system and adjacent valleys have included Ertec Western (1981); Thomas, et al. (1986); Harrill, et al. (1988); Kirk and Campana (1988); and Dettinger (1989). The sources of recent data available for the two valleys include: 1) details on water well construction from Well Drillers Reports filed with the Nevada State Engineer Office; 2) water level, spring discharge, and water chemistry data and the results of aquifer tests from the USGS databases; and 3) the results of aquifer tests and exploratory drilling into the carbonate aquifer by the Air Force during 1980 and 1981.

Other available data included technical reports of the Nevada Department of Conservation and Natural Resources, and USGS Professional Papers, Water-Supply Papers, and Open-File Reports. Characterizations of the regional setting, provide important information on the regional carbonate aquifer that is also of use in evaluating conditions in Spring Valley.

Information on the status of water rights in the valley was made available by Summit Engineering Corporation (SEC) in the form of water right abstracts which are included in Appendix B. According to SEC, these abstracts were based upon a thorough compilation and review conducted in 1990 of the public documents available from the Nevada State Engineer Office, the regulatory authority governing water rights in Nevada.

The conceptual and numerical models of Spring Valley, discussed later in the report, were based on the available site-specific and regional data discussed in the previous paragraphs, the observations made during reconnaissance trips to the valley, and the knowledge of the overall regional ground-water setting.

Methods

In assessing the water resources potential of Spring Valley, and developing a steady-state numerical model of the ground-water system of the valley, only standard approaches and procedures were used. In this section, the methods and procedures that were used are identified and discussed, along with a brief introduction to the selected numerical modelling code.

Data Collection and Compilation

Primary hydrologic data (i.e., new field measurements) were performed as part of this investigation by the MARK Group, Engineers and Geologists, Inc., and the District. Data from the USGS Water Resources Division's databases that included the most recent measurements available, were provided through the District along with well drillers reports, published reports, and maps. A literature search was conducted to identify and compile data from available published sources.

The locations and data sources were verified by comparing reported or entered data point locations and parameters with field observations and/or the published source of information. Spatial data sets (e.g., water levels, water chemistry, and water right locations), were plotted at uniform scales and annotated. The resulting maps were inspected for anomalous values and further verification was performed to resolve any anomalous data points.

Numerical Model Development

The model used to simulate the ground-water regime of Spring Valley is a computer code prepared by the USGS and referred to as MODFLOW (for "Modular Three-Dimensional Finite-Difference Ground-Water Flow Model"). The USGS has prepared comprehensive documentation for this code in one of their series of manuals on techniques of water-resources investigations (McDonald and Harbaugh, 1988). An overview of the code, a discussion of the general approach used in modelling, and the specifics of the model developed for the basin are detailed in the "Ground-Water Flow Model Development" section.

GENERAL HYDROGEOLOGIC FEATURES

The development of numerical simulations of the proposed District ground-water withdrawals in Spring Valley requires a thorough understanding of the hydrologic regime of the basin. The information that is available concerning the valley, and adjacent or similar areas, is used to develop a conceptual model of the source of water in the valley, its occurrence and flow in the subsurface, and the relationship between the valley and adjacent areas. In this section, the regional and valley-specific hydrologic conditions in Spring Valley are described and discussed.

Regional and Basin Hydrogeologic Features

Spring Valley is situated in the Alluvial Basins Ground-Water Region as defined by Heath (1984). Individual hydrographic basins in this region are characterized by alluvial basins that are underlain by bedrock, and are separated by the bedrock outcrops in the bounding mountain ranges, or, in some instances, by lower divides in alluvial terrain.

When ground water flows from one basin to another, the basins are termed a flow system. Snake Valley comprises a portion of the Great Salt Lake Desert Flow System as defined by Harrill, et al. (1988). This flow system comprises 21 individual hydrographic basins and encompasses almost 13,000 square miles. Figure 3 shows the southwestern portion of the Great Salt Lake Desert Flow System. Much of the primary recharge to this flow system is from the four basins located wholly, or in part, in Nevada, Tippett Valley, Spring Valley, Snake Valley, and Hamlin Valley. The discharge from the flow system is to the huge evapotranspiration center in the Great Salt Lake Desert and limited discharge to the Great Salt Lake.

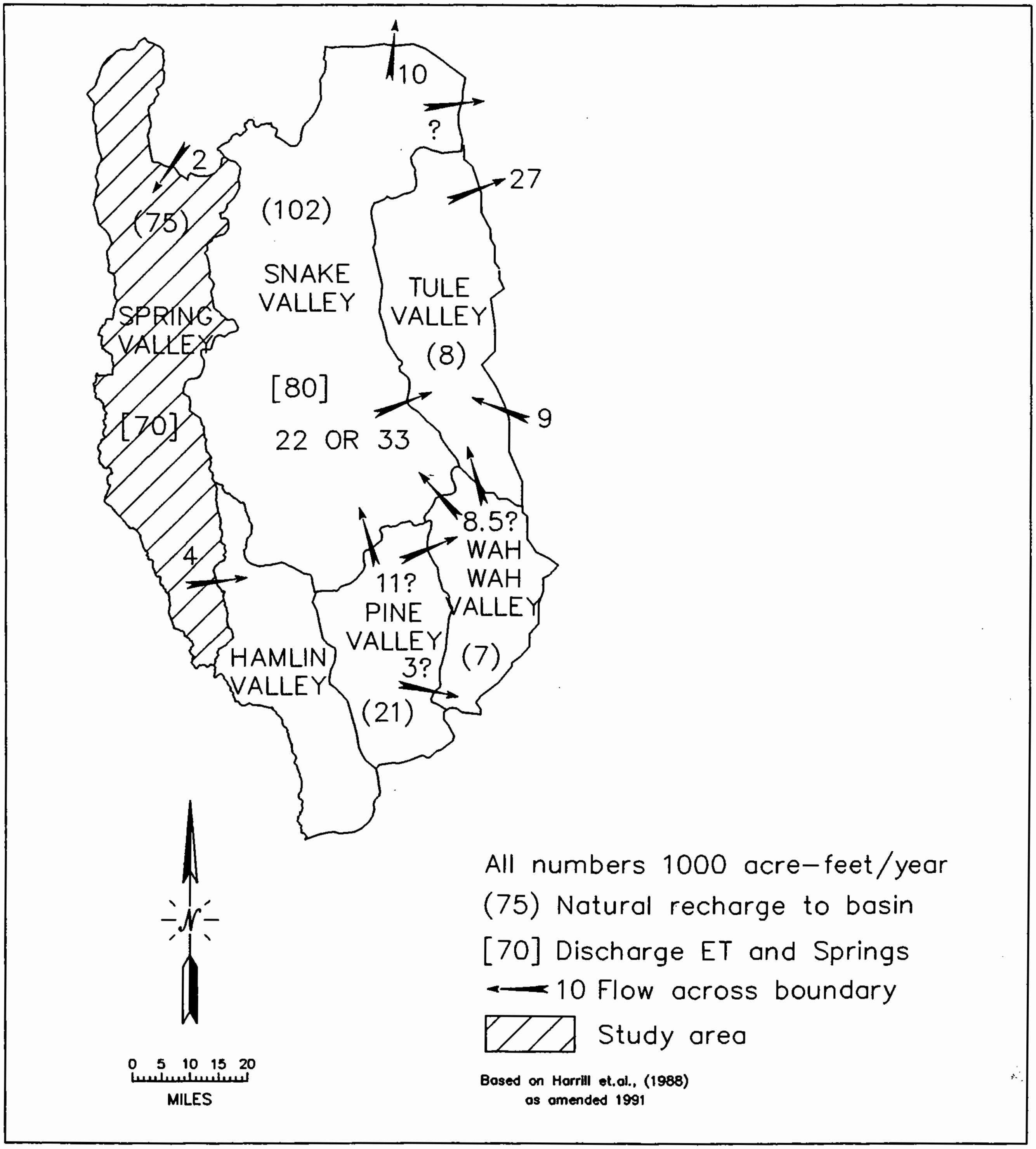


Figure 3. –– Location of Spring Valley within the southwestern part of the Great Salt Lake Desert Flow System.

The overall component of regional ground-water flow is to the south in Spring Valley, then southeast into Hamlin Valley and then to the northeast through Snake Valley and on to the eastern portions of the system. Within individual valleys in the flow system, recharge from the bounding mountain ranges results in a local flow component that generally coincides with the topography (i.e, from the mountains toward the axis of the valleys or toward playas with downward vertical hydraulic gradients). These flow directions point to the significance of major recharge areas such as the Snake Range and Schell Creek Range on regional ground-water flow patterns. The considerable recharge that occurs over these high mountain masses has resulted in hydraulic divides. On the west, the hydraulic divide that underlies the Schell Creek Range separates Spring Valley from the Goshute Valley Flow System.

Spring Valley receives an estimated 2000 acre feet per year of subsurface flow from Tippett Valley, on the north according to Rush et al. (1971) and Harrill et al. (1988) but this interpretation is questionable. As is discussed later, the available information suggests that Spring Valley is more likely hydraulically isolated from inflow from adjacent valleys.

An estimated 4000 acre feet per year of subsurface flow discharges eastward into Hamlin Valley from the southernmost part of Spring Valley. (Recent USGS publications have included Hamlin Valley within the Snake Valley hydrographic basin.) This discharge ultimately reaches the regional discharge areas of the lowlands of Snake Valley, and potentially, the Great Salt Lake Desert.

Lithologic and Hydrologic Features

The geologic units present and their ability to store and transmit ground water are important considerations in developing both conceptual and numerical models of Spring Valley. The type, thickness and depth, and water-bearing properties of the geologic materials in the valley can be used to define the overall water resources potential. In this section, the geologic units present in Spring Valley and their hydraulic properties are described and discussed.

Hydrostratigraphy

The ground-water bearing units of Spring Valley include both valley-fill deposits and consolidated rocks. For the unconsolidated valley-fill sediments that overly the bedrock in the valley, three principal units are present. These units are the younger and older alluvial deposits typical of valleys in the Great Basin and the lacustrine sediments associated with a Pleistocene lake that was present in the valley.

The stratigraphy of the consolidated rocks of the Snake Range, Schell Creek Range, Antelope Range, Fortification Range, Wilson Creek Range, and Limestone Hills have been well summarized by Hose and Blake (1976) for White Pine County and Tschanz and Pampeyan (1970) for Lincoln County. Figure 4 shows the general distribution of rocks as mapped by Plume and Carlton (1988) and the stratigraphic sequences that are present.

The consolidated rock units present, in descending order, include: 1) Older Tertiary volcanic rocks (aquifer where fractured); 2) Intrusive rocks (aquitard); 3) the Park City and Arcturus groups and the Ely Limestone (aquifer); 4) the Chainman Shale (aquitard); 5) the Joanna Limestone (aquifer); 6) the Pilot Shale (aquitard); 7) a thick sequence comprising the Guilmette formation and the Simonson, Sevy, Laketown, and Ely Springs dolomites (aquifer), 8) the Eureka Quartzite, Crystal Peak Dolomite, and Watson Ranch Quartzite (aquitard); 9) the Pogonip Group and Notch Peak Limestone or Windfall Limestone (aquifer); 10) the Dunderberg Shale, Lincoln Peak Formation, Pole Canyon Limestone, Pioche shale, Prospect Mountain Quartzite, and McCoy Group (aquitard) and their stratigraphic equivalents; this unit is commonly referred to as the clastic aquitard.

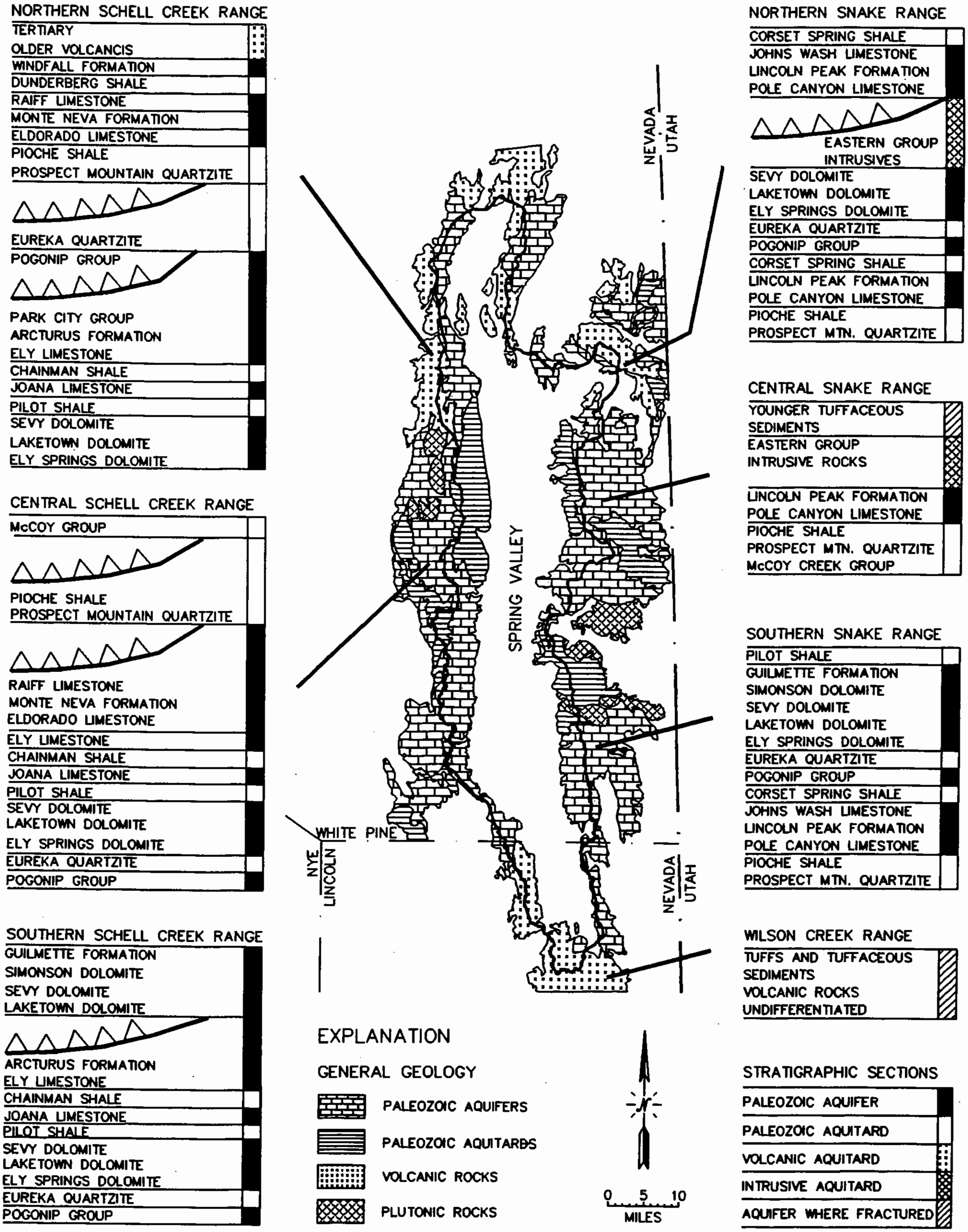
On the eastern side of the basin in the Snake Range, the stratigraphic sequence is complex. The northern portion of the range has a low angle fault complex described by Hose and Blake (1976) as "the most important single structural feature of eastern Nevada". Stewart (1980) referred to this feature as the Snake Range Thrust Fault. In the area of this decollement feature, rocks of middle and upper Cambrian age have been faulted over rocks of middle or lower cambrian age. The lower plate has been extensively intruded by intrusive bodies but the upper plate has not. The net result of the structural activity in this area is a greatly reduced thickness of mid and late Paleozoic rocks (Ordovician and younger).

In the central portions of the Snake Range an outcrop of younger tuffaceous sediments is present in the vicinity of U.S. Highway 50. These sediments overly a presumably thin sequence of Paleozoic rocks including the Lincoln Peak formation and the Pole Canyon Limestone. These units are underlain by the Pioche Shale, Prospect Mountain Quartzite, and the Precambrian quartzites and siltstones of the McCoy Creek Group.

The southern third of the Snake Range is less disturbed. In this area, a sequence of Paleozoic rocks of Devonian and younger age is present that correlates with the Pilot Shale and other underlying units in many areas in east-central Nevada.

On the north and northeast sides of Spring Valley, in the central Antelope Range, the Red Hills, and the southern Kern Mountains, the Paleozoic sequence is present and has been extensively faulted. In the Antelope Range and Kern Mountains, the faulting is predominantly low angle while in the Red Hills, normal faulting predominates. Extensive outcrops of intrusive igneous rocks of Cretaceous age occur in the Kern Mountains and volcanic rocks of older Tertiary age outcrop in the southern and northern portions of the Antelope Range.

To the west, the stratigraphy of the Schell Creek Range is quite similar to that of the Snake Range. There are considerable outcrops of older volcanic rocks only in the northern part of the range. On the eastern slopes in this area and throughout the central and southern portions of the range, sediments of Paleozoic age are present. Older Paleozoic rocks and Precambrian rocks predominate in the northern and central part of the Schell Creek Range. These units include a large north-south trending exposure of the Precambrian McCoy Creek Group and the overlying Prospect Mountain Quartzite, Pioche Shale, an unnamed limestone, the Dunderberg Shale, and



Note: There are numerous thrust plates in the Schell Creek Range. Only the major plates are shown.

Modified from Plume and Carlton (1988) and Hose and Blake (1976).

Figure 4. -- Geological and hydrogeological units in Spring Valley

the Windfall Formation. Except for the Windfall Formation, these older sediments comprise a thick (greater than 5000 ft) aquitard and are collectively referred to by Stewart (1980) as a metamorphic core complex. It appears that these sediments are a controlling factor on ground-water movement in the area.

South of T16N, the younger Paleozoic rocks predominate in the Schell Creek Range with Ordovician through Permian rocks present north of Nevada Highway 6. South of Highway 6 the upper Paleozoic sequence predominates, primarily the Pennsylvanian Ely Limestone and overlying Arcturus Formation and Rib Hill Sandstone of Permian age. These same units predominate on the southwest part of Spring Valley in the northern half of the Fortification Range. In the southern part of this range only volcanic rocks are present, tuffs and associated volcanic sediments. These same volcanics are present throughout the Wilson Creek Range except for a small block of Ordovician to Devonian rocks in the northern most part of the range.

Finally, on the southeast, a sequence of Ordovician to Devonian rocks outcrop in the Limestone Hills. This sequence, comprises predominantly dolomitic rocks that are believed to provide the avenue for the subsurface flow of ground water from Spring Valley into Hamlin Valley.

Table 2 presents the available data on the regional hydraulic characteristics of rocks and unconsolidated sediments that are present in Spring Valley. These parameters, and other features, are discussed for each modelled hydrostratigraphic unit in the following sections.

Valley-Fill Deposits

Based upon the available information, the older alluvium is presumed to be similar, hydraulically, to the younger valley-fill sediments and, for the purposes of modelling, the older and younger valley-fill may be considered as one hydrostratigraphic unit. Information concerning the thickness of the alluvium is not available. The maximum thickness of the valley fill deposits is probably several thousand feet in the central part of the basin.

The county level geologic maps do not provide good definition of the areal or subsurface extent of older and younger alluvium or the lacustrine sediments. Rush and Kazmi (1965) describe the younger alluvium as "unconsolidated, undissected, and relatively undisturbed" and mapped them only in the lower portions of the valley. These workers mapped older alluvium along the alluvial fans and noted that these sediments are "unconsolidated or poorly consolidated, dissected, poorly sorted, and commonly deformed". The lacustrine sediments, according to these workers, have an areal extent of about 310 square miles and may be as much as 300 feet thick. These sediments are underlain by sand and gravel that is presumably older alluvium.

The flow of ground water through the valley-fill aquifer occurs primarily through the interstitial porosity. However, flow is controlled by the variations in the relative permeabilities of the interbedded materials. The fine-grained deposits of the lake deposits and similar alluvial materials, although not tested in Spring Valley, can be expected to exhibit permeabilities several

Table 2.--Summary of transmissivity and hydraulic conductivity values in Nevada.

Transmissivity (ft^2/day)

Aquifer	Minimum	Maximum	Median	Number of Samples	Reference
Valley Fill	321	4,478	1,470	7	Winograd and Thordarson (1975)
	25,920	259,200	-	2	Burbey and Prudic (1985)
Tuff/Volcanic	6.7	9,090	281	5	Winograd and Thordarson (1975)
	259	-	-	1	Burbey and Prudic (1985)
Carbonate	174	11,496	1,470	11	Winograd and Thordarson (1975)
	11	250,000	2,100	31	Unpublished USGS Data
	86	43,200	4,320	5	Burbey and Prudic (1985)

Hydraulic Conductivity (ft/day)

Aquifer	Minimum	Maximum	Median	Number of Samples	Reference
Valley Fill	0.02	140	74[a]	7	Plume and Carlton (1988)
Carbonate	0.01	940	5.40	38	Unpublished USGS Data
	0.02	1.53	0.18	8	Winograd and Thordarson (1975)
Clastic	0.006	0.10	0.02	4	Unpublished USGS Data

[a] Average value for 18 tests in 14 basins

orders of magnitude smaller than sand and gravel. The interbedding of fine grained and coarse-grained sediments in the valley-fill deposits results in horizontal permeabilities that are considerably greater than vertical permeabilities.

On a regional basis, the transmissivity (a measure of the ability of an aquifer to transmit ground water) of the valley-fill ranges from about 321 to about 259,200 ft^2/day according to Burbey and Prudic (1985) and Winograd and Thordarson (1975). The transmissivity of the alluvium in a given valley or hydrologic setting is a function of both the permeability and the saturated thickness of the aquifer. Small values of transmissivity (less than 670 ft^2/day) generally indicate fair to poor well yield potential while high transmissivity wells (greater than 6,700 ft^2/day) may be capable of producing wells yields in the hundreds or even thousands of gallons per minute.

As with most of the undeveloped basins in White Pine and Lincoln Counties, and elsewhere in Nevada, data on the transmissivity of the valley-fill aquifer in Spring Valley is limited. As part of the MX Missile siting investigation a couple of aquifer tests were conducted in the alluvium in Spring Valley; however, the results of these tests are reported by Bunch and Harrill (1984) as inconclusive. As part of the water resources investigation of Spring Valley by Leeds, Hill, and Jewett, Inc. (1983) conducted for Los Angeles Department of Water and Power three wells were drilled in Spring Valley. Aquifer tests of these wells yielded the results shown in Table 3. The composite value of transmissivity for both the unconfined and confined aquifers was calculated at about 3300 ft^2 per day with the upper value for unconfined at about 5100 ft^2 per day and the lower value for confined at about 1900 ft^2 per day.

Table 3.--Range of transmissivities from Spring Valley well tests1) (ft^2/day).

Method of Analysis	Production Well 2A	Observation Well 2B	Observation Well 2C
Unconfined aquifer with full penetration (drawdown)	-	-	5,100
Confined aquifer with full penetration and no boundary (drawdown)	-	2,700	-
Confined aquifer with full penetration and recharge boundary (drawdown)	-	2,000	-
Leaky confined aquifer with full penetration and no boundary (drawdown)	-	1,900	-
Leaky confined aquifer with full penetration and impermeable boundary (drawdown)	-	1,900	-
Leaky confined aquifer with full penetration (recovery test)	3,3002)	2,000	-

1) Taken from Table 3-6 of Leeds, Hill, and Jewett, Inc. (1983).

2) This is a composite value of transmissivity since the well is actually perforated in both upper and lower aquifers.

Regionally, the hydraulic gradient (slope of the surface of the ground water) in the valley-fill aquifer is often less than 60 ft/mi, and is usually less than 30 ft/mi (Winograd and Thordarson, 1975). Because of the distribution of wells in Spring Valley, the calculation of gradients must be based upon widely separated wells and the inferred water surface between the wells. Based upon water level measurements taken at wells in and around Spring Valley in 1990 and 1991, the gradient is quite variable, ranging from steep (about 100 ft/mile or more) between the upland areas and the axis of the basin to about 10 ft/mi in the south-central part of the basin. On a local basis, the gradients in the vicinity of operating water wells may also be steep.

Consolidated Rock

The carbonate aquifers present in Spring Valley consists of thick sequences of Paleozoic limestones and dolomites separated by thinner aquitards comprising shale or quartzite. Collectively, the Paleozoic rocks that are present comprise the numerous individual rock units that were previously discussed, and have an overall thickness of as much as 30,000 feet. Flow through the carbonate aquifers is believed to occur primarily through fractures and solution openings, and is likely to be concentrated in areas of greater fracture frequency. Except in areas of structural or stratigraphic anomalies, the hydraulic gradient in the carbonate aquifers is likely to be small because of high transmissivity.

The movement of ground water across the contact between the valley-fill aquifer and the carbonate aquifer depends on the potentiometric heads (elevation of the water table or piezometric surface) in each aquifer. In areas where the head is higher in the valley-fill, the ground water is semi-perched and moves principally downward into the underlying carbonate, serving to recharge the regional carbonate aquifer. Where the head in the carbonate aquifer is higher than the valley-fill, ground water can enter the overlying alluvial material through upward leakage from the carbonate rocks.

The Paleozoic sediments underlie the alluvial deposits at depth under all of Spring Valley but probably are separated from the valley-fill deposits by volcanic rocks in the northernmost part of the basin. Although four discrete rock aquifers comprising sediments of Paleozoic age can be identified, the structural deformation that has occurred in the valley has resulted in the overlapping of these aquifers. Thus for the purposes of developing a numerical model of the area, the entire Paleozoic sequence may be considered as a single aquifer. In siting locations for bedrock wells, the location of confining units within this sequence such as the Chainman Shale and Eureka Quartzite should be given careful consideration.

Data concerning the hydraulic properties of the consolidated rock aquifers of Spring Valley are lacking. In the nearby valleys, the transmissivity of the carbonate aquifer has been found to range from 11 to 250,000 ft^2/day (Winograd and Thordarson (1975); Burbey and Prudic (1985); and unpublished U.S. Geological Survey data), with values as high as several hundred thousand ft^2/day possible in fractured areas (Winograd, 1963; Winograd and Thordarson, 1975). Variations in structural setting, proximity to faults, mechanical rock properties, depositional environment, and aquifer thickness are the chief parameters that account for the large variations in the transmissivity of carbonates.

In general, it is inferred that the transmissivity of the carbonate aquifer in Spring Valley is variable with the highest transmissivities occurring in the vicinity of major structural elements such as north-south trending normal faults and the southeast trending faults in the southern Limestone Hills and the Sacramento Pass area of the Snake Range. In these areas, dissolution of the carbonates results in high secondary porosities and very high transmissivities. In the relatively undisturbed areas between such structural features the transmissivities are probably appreciably lower because of the inferred lesser degree of development of secondary porosity.

The Tertiary volcanic rocks that crop out in the mountains of northern Spring Valley probably represent a partial hydraulic barrier to ground-water flow. These rocks consist of tuffs and other volcanoclastic rocks that generally form aquitards. Where extensively fractured however, these rocks can yield moderate quantities of ground water to production wells. The older intrusive rocks are also of note. The intrusives of the Kern Mountains and central Snake Range are probably effective aquitards.

The clastic aquitard, a metamorphic core complex (Stewart, 1980), is composed of Precambrian and Cambrian siltstones, quartzites, shales and sandstones. Ground-water potentials are likely to be greatly affected by this unit because of the low transmissivity. In fact, recharge and discharge areas are often determined by the location and orientation of this unit. Ground water will tend to flow along the dip of this barrier rather than through it. The aggregate thickness of this unit is approximately 10,000 feet; however, local thickness varies with structure.

Structural Features

Faulting within Spring Valley is generally consistent with features typical of the Basin and Range Province (i.e., horst and graben structures oriented along north and northeast-trending normal faults). The Basin and Range is dominated by north-south trending fault scarps and lineaments that cut through the alluvium (Hose and Blake, 1976 and Tschanz and Pampeyan, 1970). Several periods of regional tectonism have faulted, fractured, and displaced both bedrock and valley-fill materials.

Of particular note are the thrust faults that are present in the Snake, Antelope, and Schell Creek ranges. These low angle features have faulted older rocks onto the top of younger rocks. These faults are of particular significance in that they can double the thickness of the aquifers (and aquitards) that are present in the shallow subsurface. The tectonism has also greatly reduced the overall thickness of post-Cambrian units present in some areas. As noted by Hose and Blake (1976), less than 1000 feet of post-Cambrian sediments remain in an area where as much as 20,000 feet of sediments were originally deposited.

Along the eastern flanks of the Schell Creek Range, Precambrian sediments of the McCoy Group have been thrust over the middle Cambrian units. A spring line comprising more than 60 springs and extending more than 35 miles occurs in the alluvial deposits to the east of this structure. This limits of this spring line are coincident with the outcropping of the Precambrian sediments and suggests that a buried contact between the alluvium and the Precambrian is the cause of this spring line. Smaller and less continuous spring lines are also present to the west in the higher elevations of the Schell Creek Range. Many of these smaller spring lines appear to be coincident with the contact between the Precambrian units and the lower Cambrian units.

Also of note are faults that are not north-south trending such as the east-west trending faults in the southern Limestone Hills. Existing data suggests that ground-water movement along these faults occurs with flow from Spring Valley into Hamlin Valley. Where these faults intersect north-south trending faults that occur along the mountain fronts, large scale dissolution of the carbonate aquifers may have occurred. Such intersections are generally more favorable for ground-water development than areas where faulting is absent.

WATER RESOURCES APPRAISAL

To develop a steady-state ground-water flow model that is representative of Spring Valley's hydrologic system, it is necessary to define the magnitude of the water resources available in the basin and the basin's development history. The following sections present the available information on the surface and ground-water resources of the valley.

Figure 5 shows a conceptualization of the overall hydrologic system of Spring Valley. Each of the major components of the water budget for the valley are discussed in detail in the following sections. It should be noted that although there are numerous wells in the basin and a reconnaissance level study has been done by the USGS (Rush and Kazmi, 1965), detailed hydrologic studies, however, have not been conducted. Therefore, the development of the conceptual model of the valley must rely, in part, upon inference based upon the data and interpretations that are available and analogy to other basins in eastern and southern Nevada that share similar characteristics.

Surface Water

An accurate simulation of a hydrogeologic system requires an understanding of the surface water conditions and the significance of surface water in the overall water budget for a given hydrographic basin. This section describes the general conditions of the surface water regime of Spring Valley.

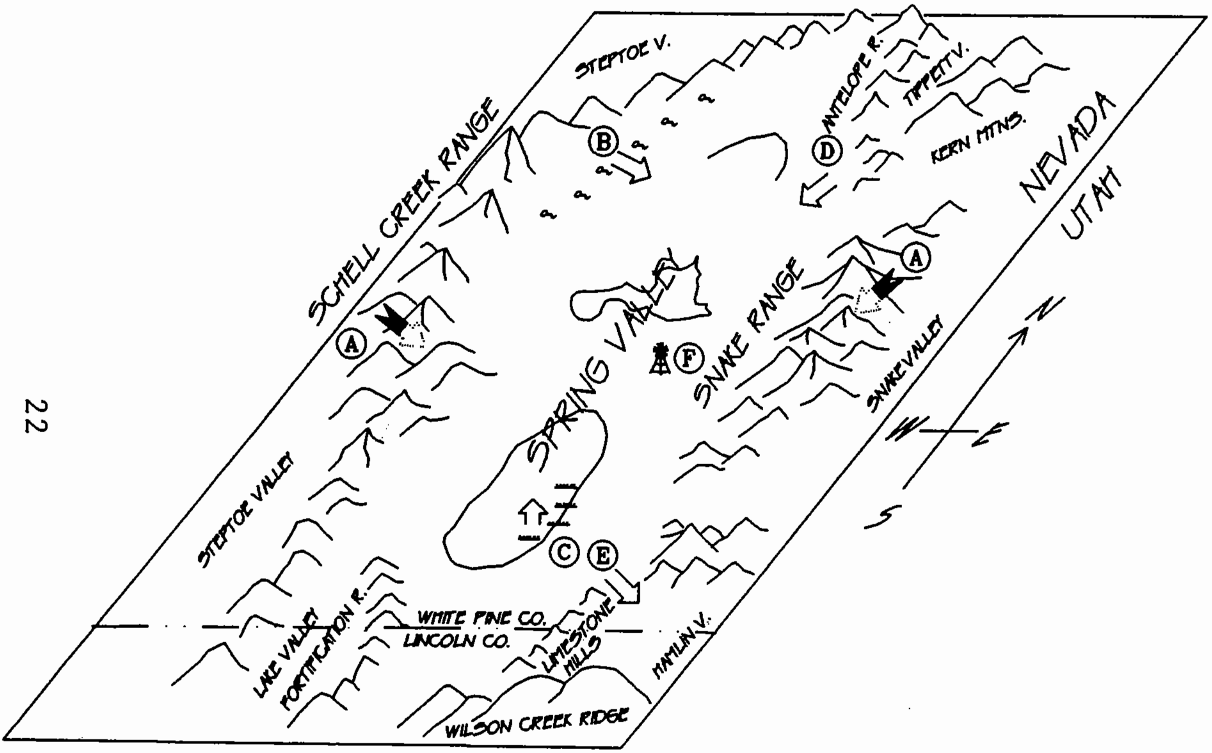
General Conditions

Given its location in the arid Great Basin, the surface water resources of Spring Valley are appreciable. The hundreds of springs that occur throughout the valley support the baseflow for a number of streams. Snowmelt from the upland areas generates peak flows each May and June of each year with many streams discharging thousands of acre-feet per year to the valley floor area. These water resources support significant agricultural areas.

Because of the seasonal use of water for irrigation, surface water supplies are not used during much of the year. Rush and Kazmi (1965) noted that this water "runs to waste" by evaporation and represents a significant under utilization of the surface water resources in Spring Valley.

Available Records

Gaging data collected by the USGS are available for a number of streams (Garcia et al., 1992). Major streams that drain the eastern slopes of the Schell Creek Range include Cleve Creek,



Ⓐ Ground water in Spring Valley originates as precipitation over the mountain areas. Almost one million acre feet of rain and snow fall over the drainage basin each year, mostly over the Schell Creek and Snake ranges. About 75,000 acre feet per year of this water recharges the shallow ground–water system.

Ⓑ Numerous springs discharge in the upland areas and in springlines on the alluvial fans. These springs feed the streams of the area and provide important sources of water for agriculture, ranching and wildlife.

Ⓒ Shallow ground water occurs over a large area of Spring Valley. A significant amount of ground water evaporates from bare soils and is transpired by plants. The total evapotranspiration in Spring Valley is at least 70,000 acre feet per year.

Ⓓ A small quantity of ground water, an estimated 2,000 acre feet per year is contributed to Spring Valley from Tippet Valley on the northeast.

Ⓔ Ground–water discharge from Spring Valley to other valleys is limited. About 4,000 acre feet discharge across the southwest boundary of the basin into Hamlin Valley.

Ⓕ Ground–water withdrawals for agriculture amount to about 8,000 acre feet per year. Another 2,000 acre feet per year is estimated to be withdraw for mining, domestic, and stock needs.

Figure 5. –– Conceptual model of the hydrology of Spring Valley

Kalamazoo Creek, Siegel Creek, North Creek, Muncy Creek, Taft Creek, McCoy Creek, Bassett Creek, and Odgers Creek. Only two major streams drain the Snake Range, Willard Creek, and Spring Creek. Spring Valley Creek, in the northernmost part of the valley drains parts of both the Schell Creek Range and the Antelope Range. Flows in these creeks are fed by springs, snowmelt and runoff from winter and summer rainfall events.

Continuous discharge measurements are only available for a single gaging station on Cleve Creek. Figure 6 shows the monthly maximums, minimums, and averages of Cleve Creek. The average discharge for this creek, based upon 21 years of record, is 10.1 cfs. It should be noted that the flow is highly variable however. In water year 1991 for example, the mean discharges between October 1990 and April 1991 ranged from 4.52 to 5.2 cfs. Mean discharge in May rose to 8.51 cfs and in June to 25.0 cfs reflecting the appreciable contribution from snowmelt. Mean discharges in July through September 1991 steadily declined from 7.14 to 5.48 cfs. The minimum discharge recorded occurred in February 1960 when a rate of only 2.3 cfs was recorded. The maximum discharge of 440 cfs was estimated for May 1983. In water year 1991, the maximum discharge rate was 42 cfs on the 5th of June.

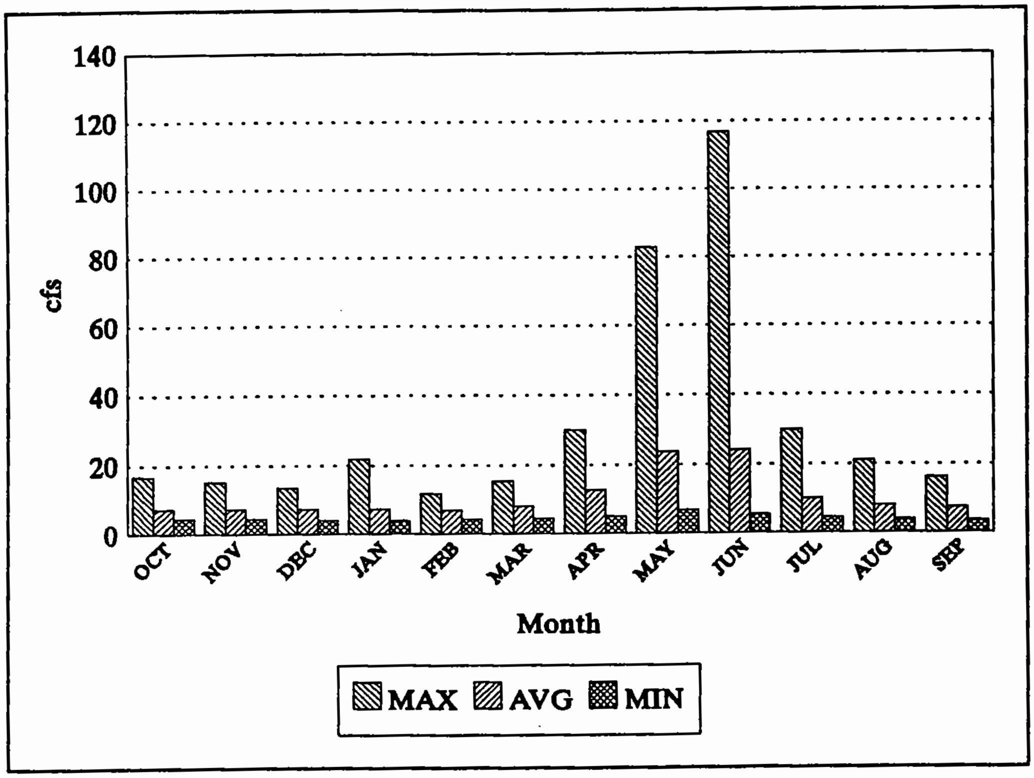


Figure 6.--Select streamflow characteristics for Cleve Creek in Spring Valley Nevada for the water years 1960-1992.

Records for other streams are limited a few measurements taken in water year 1991 that are presented in Garcia et al. (1992) and Bunch and Harrill (1984). Kalamazoo Creek was measured at 0.31 cfs in November 1990, at 0.29 cfs in March 1991, and 4.42 cfs in July 1991. Other measurements taken in July 1991 include Odgers Creek (2.51 cfs), Bassett Creek (4.65 cfs), Taft Creek (2.51 cfs), and Willard Creek (0.46 cfs). The mean discharge for 12-18 July 1991 at Cleve Creek (when the other measurements were taken) ranged from 6.6 to 7.7 cfs and averaged 7.0 cfs, close to the mean annual discharge rate of 7.25 cfs.

Stream discharge measurements were taken in June 1980 as part of Air Force investigations in Spring Valley. Kalamazoo Creek was gaged at 4.0 cfs, McCoy Creek at 6 7.8 cfs, Taft Creek at 12.9 cfs, Cleve Creek at 26.7 cfs, Pine Creek at 5.8 cfs, and Williams Creek at 10.2 cfs. These data were collected during the peak discharge period and, when compared with water year 1991 records, indicate that the same seasonal variation observed at Cleve Creek is common to the streams of the basin.

Measurements taken in July 1964 for other creeks are presented by Rush and Kazmi (1965) and include Dry Canyon and Williams Canyon Creeks (3 cfs), Pine and Ridge Creeks (3 cfs), two unnamed creek (3.1 cfs), McCoy Creek (9.52 cfs), Muncy Creek (4.23 cfs), North Creek (2.23 cfs) and Seigel Creek (2 cfs) If it is assumed that the measurements taken in July 1991 and 1964 are representative of mean annual conditions, then the total discharge from the creeks that were gaged is 48.9 cfs or about 35,000 acre-feet per year. Flow in the washes in both valleys is ephemeral, occurring in response to the infrequent precipitation over the drainage area. No surface water measurements or estimates are available for the washes in Spring Valley.

Runoff

The total quantity of runoff from the mountains bounding Spring Valley is not known, but Moore (1965, in Rush and Kazmi) estimated total runoff at 90,000 acre-feet per year. Runoff is derived from two major sources, snowmelt, and rainfall. As discussed previously, the total flow in gaged streams is about 35,000 acre-feet per year. If the baseflow conditions for Cleve Creek are representative, then about half of this discharge is from ground water and half from snowmelt and precipitation, of which snowmelt is undoubtedly the major contributor. The distribution of the streamflows is quite seasonal with the major runoff event associated with snowmelt typically occurring in May and June.

Heavy runoff events may result in short-duration flows along reaches of normally dry washes in the lower parts of the valley; however, some amount of this runoff infiltrates along the upper parts of the alluvial fans, directly into open fractures in the consolidated rock areas, and into the coarse streambed deposits of the channels that drain the area. Much of this water is transpired by vegetation or simply evaporates. That portion of the precipitation over the basin that does not runoff, but infiltrates through the unsaturated zone to recharge the aquifers, must be accounted for in the model. However, this recharge is accounted within the model independently and does not require the simulation of rainfall (and snowfall) and runoff.

Moore (1965, in Rush and Kazmi) estimated that a total of 90,000 acre-feet per year of runoff occurs in Spring Valley with most (71,000 acre feet) contributed from the Schell Creek Range. Given the elevation and extent of the Snake Range, the disproportionate contribution of runoff from this source warrants further discussion. Moore (1965, in Rush and Kazmi) states:

> "The high mountains of the southern part of Snake Range (the Wheeler Peak area) would generally be expected to produce more runoff than is computed... Several factors may cause the reduction from the anticipated amounts, two of the factors being less than expected precipitation and unfavorable geologic structure... [east dipping fault zones] may be highly permeable and transmit large quantities of water to the eastern side of the range, where it is discharged as spring-fed mountain streams."

While it is agreed that geologic structures are a controlling factor on ground-water recharge, the inference of east flowing recharge from the west slopes of the Snake Range is questionable. The water budget for Snake Valley (as presented in Hood and Rush, 1965) does not appear to include an increase in either the runoff or recharge rates. In fact, the recharge rates for Snake Valley, as estimated by these workers for areas above 8000 feet, are less than those in Spring Valley. The presence of numerous spring lines on the western slopes of the Snake Range and on the floor of Spring Valley indicate that there is a significant source of ground water from the Snake Range. That the runoff is disproportionately low does seem to indicate, as suggested by Moore (1965, in Rush and Kazmi) that the recharge rate is higher than would be expected on the basis of rock type alone.

The Wheeler Peak area is underlain near the surface by Cambrian quartzites and shales, and Precambrian siltstone, quartzites, and conglomerates. At depth these rocks are probably underlain by Jurassic intrusive rocks of the eastern group) as evidenced by the circular outcrops of these granitic rocks around the entire Wheeler Peak area. Uplift associated with the emplacement of this pluton may very well have greatly altered the hydraulic properties of the overlying Cambrian rocks. These units contain thick sequences of shaly and argillaceous limestones that, while generally only poor aquifers, can transmit significant volumes of water when intensely fractured.

The occurrence of numerous distinct spring lines in the vicinity of this intrusive mass suggests that flow is radial from the upland area toward both Spring Valley and Snake Valley. About 25 springs on the west slopes of the Snake Range are shown on 1:100,000 topographic maps of the area. Another 17 springs occur in the downgradient alluvial slopes. Some of the spring lines are situated near the contact between the intrusive rocks and the overlying sediments suggesting that contrasts in the permeability of differing lithologies has a major effect on ground-water flow. That similar spring lines occur in the alluvial portions of the valley suggests that this effect is only partial and that leakage across this contact occurs. The spring lines in the valley may be a result of the buried contact between the alluvium and the underlying Paleozoic sediments.

Ground Water

It is necessary to understand the conditions and characteristics of the ground water in Spring Valley to develop an accurate numerical simulation. This section discusses the ground water occurrence, source, movement, chemical quality, and budget for Spring Valley.

Occurrence

Ground water occurs in Spring Valley at shallow depths over much of Spring Valley. There are a number of flowing wells in the Baking Powder Flat area in the southern and central parts of the valley and two flowing wells are reported in the northernmost part of the basin. Elsewhere, the depth to water over a large area of the valley floor is less than 20 feet and almost the entire valley floor area south of T20N and north of T9N has ground water at 50 feet or less below land surface (Rush and Kazmi, 1965). The deepest water in the basin occurs under the alluvial fan areas, about 200 feet or more on the fan between the Red Hills and Kern Mountains to a maximum of about 420 feet in the high alluvium at the southern end of the valley.

Figure 7 shows the regional potentiometric surfaces for Spring Valley based upon the water level data for the valley and vicinity, and an evaluation of potentiometric data for the Great Salt Lake Desert flow system as a whole. The potentiometric surface shown is believed to represent a reasonably accurate conceptual picture of the water underlying the basins. The many springs that occur in the bounding mountains indicate that a significant ground-water mound occur under both the Schell Creek Range and Snake Range. These ground-water highs reflect the higher precipitation that occurs over these mountains.

In the valley floor areas the potentiometric surface ranges from almost 6,700 feet AMSL in the northernmost part of the valley to less than feet AMSL about 5,760 feet AMSL at the south end of the valley near the topographic divide with Snake Valley. Water levels over the rest of the valley floor range from about 5,800 to 5,600 feet AMSL. Locally, water levels vary by only a few tens of feet.

Data are generally lacking on the temporal variations in water levels in Spring Valley. Although variations of as much as 15 feet of water may occur from year to year, no long-term change in the water levels over the basin area apparent from the available data. For example, a well located at 13N-67E 8ACA has water level data available for the period from 1953 through 1990. The water level in 1954 was about 14 feet below land surface, the same as in 1990. Another well, at 15N-66E 13D shows a similar trend with a depth to water of about 14 feet in both 1952 and 1991. These data suggest that although seasonal and annual variations may occur, the overall water levels in the basin have remain essentially constant for the last 40 years. And this further means that the basin is in a steady state condition where inflow equals outflow.

Head elevation data for the carbonate aquifer are lacking. The strong vertical hydraulic gradients in the central portions of the basins, as evidenced by the numerous flowing wells, suggest that the heads elsewhere in the carbonate aquifer are equal or higher than those in the valley-fill aquifer.

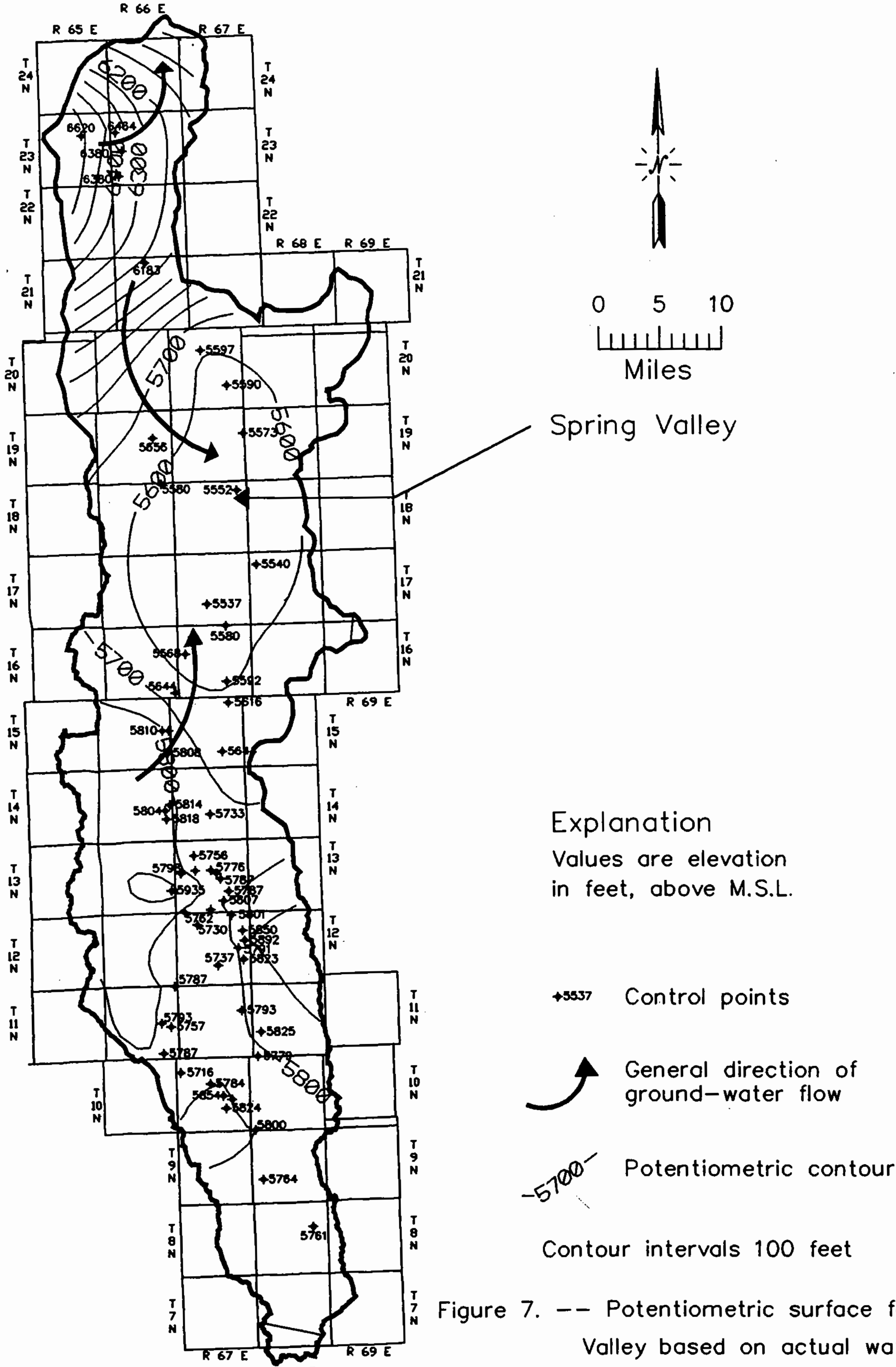


Figure 7. -- Potentiometric surface for Spring Valley based on actual water levels.

Source

The source of ground water within Spring Valley is from recharge of precipitation over the Schell Creek and Snake ranges. Lesser amounts of recharge are derived from the eastern and southern bounding mountain ranges. The basin is closed topographically and no water is contributed from other basins through surface water flow. Subsurface flow from Tippett Valley, on the order of 2000 acre-feet per year may be occurring, according to Rush et al. (1971) and Harrill et al. (1988). This subsurface recharge was not included in the perennial yield estimate made by Rush and Kazmi (1965) and, as discussed below, may be somewhat less. The results of the modelling, described in later sections of this report, indicates that this inflow may total about 1,700 acre-feet per year.

Movement

Ground-water flow seems to be primarily controlled by the location of the source areas high in the surrounding mountains. In general, ground water flows eastward from the Schell Creek Range and westward from the Snake Range toward the valley axis where it is discharged to wells and evapotranspiration. In the southern part of the basin, the water level elevations decline to the southeast toward Hamlin Valley.

On the northeast, in the area where Rush et al. (1971) and Harrill et al. (1988) indicate subsurface flow from Tippett Valley into Spring Valley, the available data suggest that less flow is occurring. Thomas et al. (1986) indicate a water level elevation of 5,510 feet AMSL in southern Tippet Valley while the unpublished USGS data indicate water level elevations of more than 5,590 feet AMSL in the closest wells in Spring Valley. The divide between the two basins ranges from in elevation from 6,863 feet AMSL at Tippett Peak on the northwest to about 5,900 feet AMSL on the alluvial divide, to a maximum of 7,522 feet in the Red Hills, to 9,630 feet at a peak in the Kern Mountains. The elevation across this section is within the range where ground-water recharge occurs. Based upon the limited water level data and the topography, it is considered likely that a ground-water divide coincides with the topographic divide and there is only limited flow between Tippett Valley and Spring Valley.

Ground-water heads in northern Lake Valley are higher than those in southwestern Spring Valley. Regional ground-water level data presented by Thomas et al. (1986) indicate that flow in Lake Valley is to the south toward Panaca. The upper Paleozoic carbonates of the Fortification Range separate the two basins and the water level data on either side of this range indicates flow away from the range both the southwest to Lake Valley and to the northeast to Spring Valley. It is considered likely that a ground-water divide in the Fortification Range roughly coincides with the basin boundary through this area and that there is no flow between the two basins.

There is evidence to support discharge from southern Spring Valley into Hamlin Valley, estimated at 4000 acre-feet per year by Rush and Kazmi (1965). In the southern part of the Baking Powder Flat area, water levels are about 100 feet higher than in the western part of

Hamlin Valley. Tschanz and Pampeyan (1970) map the carbonates of the Limestone Hills, which outcrop between the two basins, as Devonian, Silurian, and Ordovician dolomites. Their geologic map of Lincoln County also shows two northwest trending faults through the pass that separates the Limestone Hills on the south from the Wilson Creek Range. It is likely that secondary dissolution of fractures along this fault zone has resulted in a highly transmissive zone that drains southern Spring Valley into Hamlin Valley.

Using water level data in each basin and an estimated flow path width of about 7000 feet, the gross transmissivity of this zone would have to be on the order of 25,000 ft^2/day to allow the discharge of the estimated 1,500 acre-feet per year into Hamlin Valley. Such a transmissivity would be reasonable for a fault zone of this type. If the entire length of the carbonate units between the two basins north of this fault zone is considered (almost 13 miles) and a median transmissivity value of 4,320 ft2/day (Burbey and Prudic, 1985 and Table 1) is assumed, then the overall gradient of .001 suggests that flow on the order of 2,500 acre-feet per year. With flow through the fault zone to the south, the total interbasin flow is estimated at 4000 acre feet per year. Based on these considerations, the estimate by Rush and Kazmi (1965), is considered reasonable and the boundary conditions of the numerical model of Spring Valley were set to simulate this quantity of flow.

Chemical Water Quality

The chemical quality of the ground water in Nevada depends on its location. The chemical concentration in recharge areas is normally very low; however, the ground water comes into contact with soluble rock materials for long periods of time as it moves towards discharge areas where the chemical concentration is higher. The solubility, volume, distribution of rock materials, time of water contact with the rocks, temperature, and pressure in the ground-water system are factors that determine the extent to which the chemical constituents from the rock materials will be dissolved.

General

The water quality in Spring Valley varies between streams and ground water and is dependent upon the geology, resident time, and temperature. Streams, supplied primarily from snow melt are of very good water quality typified by very low electrical conductivity (EC). Springs in the Valley have higher EC values than the streams and EC is higher in the eastern and northern part of the valley. Wells in the area, from data presented by Bunch and Harrill (1984), show higher EC values than most of the springs with shallow wells having the highest EC. Overall the water quality is very good. Surface water samples from creeks on the west side of the valley ranged from 30 to 52 μmhos/cm. Springs have an (EC) range of 74 to 485 μmhos/cm. Well EC (data from Bunch and Harrill, 1984) ranges from 112 to 975 μmhos/cm.

Streams

Perennial streams in Spring Valley are abundant and the majority are located in the Schell Creek Range on the west side of the Valley. Water quality is excellent with very low EC. Seasonal fluctuations occur with lowest EC during spring runoff moderate increases over the remainder of the year as runoff decreases. The data from the streams are presented in Tables 4 and 5.

Springs

In 1991 a reconnaissance sampling of springs in Spring Valley was completed at 18 sites. EC, pH, temperature, and alkalinity measurements were taken in the field and Ca^{2+}, Mg^{2+} samples were collected for laboratory analysis. Based upon the results of the reconnaissance 5 springs were sampled in 1992 for major ions, radioactive isotopes ^{13}C, ^{14}C, tritium, and stable isotopes ^{18}O and deuterium. The data from field reconnaissance and major ion chemistry are presented in Tables 4 and 5, respectively.

Figure 8 shows the location of the springs sampled during the reconnaissance and the respective EC. Springs in the northern valley have a higher EC, greater than 400 μmhos/cm, than the majority of the springs sampled which is attributed to the presence of volcanic deposits (see Figure 4 for geology). Two springs in the east central part of the valley, South Millick and Bubbling Sand, also display EC values in excess of 400 μmhos/cm. The higher EC for these wells is most likely from longer flow paths as the springs are located in the east central part of the valley. The remainder of the springs have EC values less than 300 μmhos/cm with springs closer to the mountain block having the lowest EC.

Age dates from ^{14}C samples from four springs sampled range from 4550 to 8510 years before present (Table 6). Tritium data, Table 6, is below detection limits for the springs sampled with the exception of North Shoshone Spring, which had a value of 23 pCi/ℓ. The presence of tritium at the spring in conjunction with the ^{14}C age date of 6110 years before present suggests a mixing of older and younger ground water.

Stable isotope data for ^{18}O and Deuterium for the springs and creeks sampled is presented in Table 6 and is shown plotted with the meteoric water line in Figure 9. Generally the data becomes isotopically lighter to the north of the valley, becoming lightest in the area of Piermont and McCoy Creeks. The isotopic signatures coincide with the elevation of the drainage, with the isotopically lightest values in the areas that have the greatest elevation. With the exception of Millick Spring the data falls on the meteoric water line and values are typical of precipitation at cold temperatures and high elevations. Millick Spring plots to the right of the meteoric water line which indicates fractionation from evaporation.

Major ion data from the springs plotted on a trilinear diagram Figure 10, show that the water is a calcium, magnesium, bicarbonate ion dominated water. Figure 11, modified from Mifflin, 1968, shows that spring samples plot in the areas designated as either local or low flow local in origin. This plot in conjunction with the ^{14}C dates indicate that Spring Valley does not have a regional flow component as part of its ground-water system.

Wells

Ground-water samples taken from wells in Spring Valley display higher EC than either stream or spring samples (data from Bunch and Harrill, 1984). Well location, EC, and completion depths are shown in Figure 12. Major ion chemistry is presented in Table 5. As shown in Figure 12 the highest EC values correspond to wells that have shallow completion depths which indicates the concentration of salts from evapotranspiration. The overall higher EC at deeper wells is attributed to longer resident time and deposits in which the wells are completed. The trilinear diagram presented in Figure 10 shows that the well samples are primarily calcium, magnesium, bicarbonate ion dominated but with a higher percentage of sodium, chloride, and sulfate ions relative to the spring samples.

Table 4. - Data from 1991 spring reconnaissance sampling in Spring Valley.

Name	Date	Discharge	Temp	pH	EC	CO_3^{2-}	HCO_3^-	Ca^{2+}	Mg^{2+}
		gpm	°C		µmhos/cm	mg/ℓ			
Bastian Spg Well	10/24/91	2.0	10.7	7.97	269	0	144	34.2	13.50
"Big Scum"	10/24/91	NA	9.1	8.39	289	0	158	39.3	15.00
"Bubbling Sand"	10/24/91	20.0	11.0	7.59	485	0	239	56.1	25.10
The Cedars	10/22/91	100.0	21.0	8.31	138	0	63	19.9	2.14
"Dugout"	10/23/91	20.0	4.8	8.18	476	0	255	70.9	19.60
"Garret Can."	10/23/91	5.0	6.8	7.84	390	0	172	48.6	16.20
Layton	10/24/91	NA	10.0	9.92	228	60	28	20.8	8.35
McCoy Ck	10/24/91	20.0	2.8	8.04	36	0	15	3.6	1.28
E McCoy	10/24/91	100.0	8.2	6.77	74	0	27	7.8	2.18
S. Millet	10/24/91	10.0	13.5	7.65	431	0	219	49.3	24.40
North	10/22/91	25.0	11.1	8.28	NA	0	215	47.4	25.20
Osborn	10/23/91	5.0	8.2	8.16	350	0	154	46.1	11.30
"E of Piermont"	10/24/91	5.0	10.2	6.88	131	0	47	14.4	4.13
"So of Ranch"	10/23/91	NA	9.4	7.68	427	0	168	63.1	9.72
Shellbourne P	10/23/91	10.0	7.0	8.37	434	0	164	50.5	8.16
N Shoshone	10/22/91	300.0	13.0	8.09	269	0	159	37.9	12.10
"Stone House"	10/23/91	seep	6.8	8.20	1655	0	584	102.0	61.10
Taft Ck	10/24/91	2.0	5.8	7.91	30	0	11	3.3	1.01
Willard	10/24/91	10.0	13.6	7.57	238	0	108	28.5	5.29
Willow	10/23/91	5.0	11.8	7.76	434	0	194	54.3	13.30

Table 5.--Major ion chemistry data for select creeks, springs and wells in Spring Valley.

SPRING	DATE	EC	Si02	pH	HCO_3^-	Cl^-	SO_4^-	NO_3^-	Na^{2+}	K^+	Ca^{2+}	Mg^{2+}
		µmhos/cm	mg/ℓ		concentrations in mg/ℓ							
THE CEDARS	5/27/92	146	22.3	8.23	86.1	1.9	4.03	0.62	9.03	1.03	22.3	0.67
N. SHOSHONE SPR.	5/27/92	263	11.8	8.17	172	1.3	4.08	1.33	2.6	0.73	35.9	11.6
PIERMONT CREEK	5/28/92	53	8.1	7.5	25.3	1	3.75	0.04	2.56	0.57	6.23	1.54
McCOY CREEK	5/28/92	25.2	5.8	7.12	9.9	0.6	1.85	0.97	1.49	0.39	2.69	0.64
S. BASTIAN SPR.	6/18/92	261	20.4	8.07	180	1.6	6.07	1.06	6.99	1.91	34.1	12.8
E OF PIERMONT	6/18/92	142	3.7	7.04	54	9.2	9.5	0.93	6.08	1.22	15.8	3.83
WELL *	1950	309	N/A	N/A	141	16	22	N/A	34	--	24	7.4
WELL *	1980	460	N/A	N/A	200	13	56	N/A	35	2.9	39	17
WELL *	1950	112	N/A	N/A	63	5	3	N/A	12	--	10	3.6
WELL *	1964	975	N/A	N/A	264	85	148	N/A	120	--	47	26
SPRING *	1964	257	N/A	N/A	172	4.7	12	N/A	15	--	38	7.8
WELL *	1980	575	N/A	N/A	360	14	ND	N/A	20	1.5	56	27
WELL *	1964	911	N/A	N/A	521	23	36	N/A	110	--	58	30
SPRING *	1980	--	N/A	N/A	--	2.2	5.0	N/A	3.7	0.5	53	7.0
WELL *	1964	626	N/A	N/A	346	23	26	N/A	21	--	65	33
WELL *	1964	499	N/A	N/A	220	19	63	N/A	22	--	48	26
WELL *	1980	--	N/A	N/A	176	25	46	N/A	43	2.6	26	10
WELL *	1950	161	N/A	N/A	84	7.0	7	N/A	14	--	17	3.3
WELL *	1964	395	N/A	N/A	204	8.0	34	N/A	12	--	39	22
WELL *	1964	750	N/A	N/A	239	80	52	N/A	82	--	61	14
WELL *	1954	158	N/A	N/A	88	3.5	5	N/A	16	--	18	1.0
WELL *	1980	--	N/A	N/A	--	2.6	4	N/A	9.2	1.1	20	2.7
WELL *	1980	--	N/A	N/A	--	5.4	12	N/A	7.8	1.2	30	21
WELL *	1980	--	N/A	N/A	--	1.5	6	N/A	3.8	0.6	47	10
SPRING *	1980	--	N/A	N/A	--	1.1	4	N/A	1.4	0.4	48	8.8
SPRING *	1964	236	N/A	N/A	122	11	11	N/A	14	--	24	6.8
WELL *	1980	--	N/A	N/A	133	12	8	N/A	9.6	3.3	24	12

* Data from Bunch and Harrill, 1984

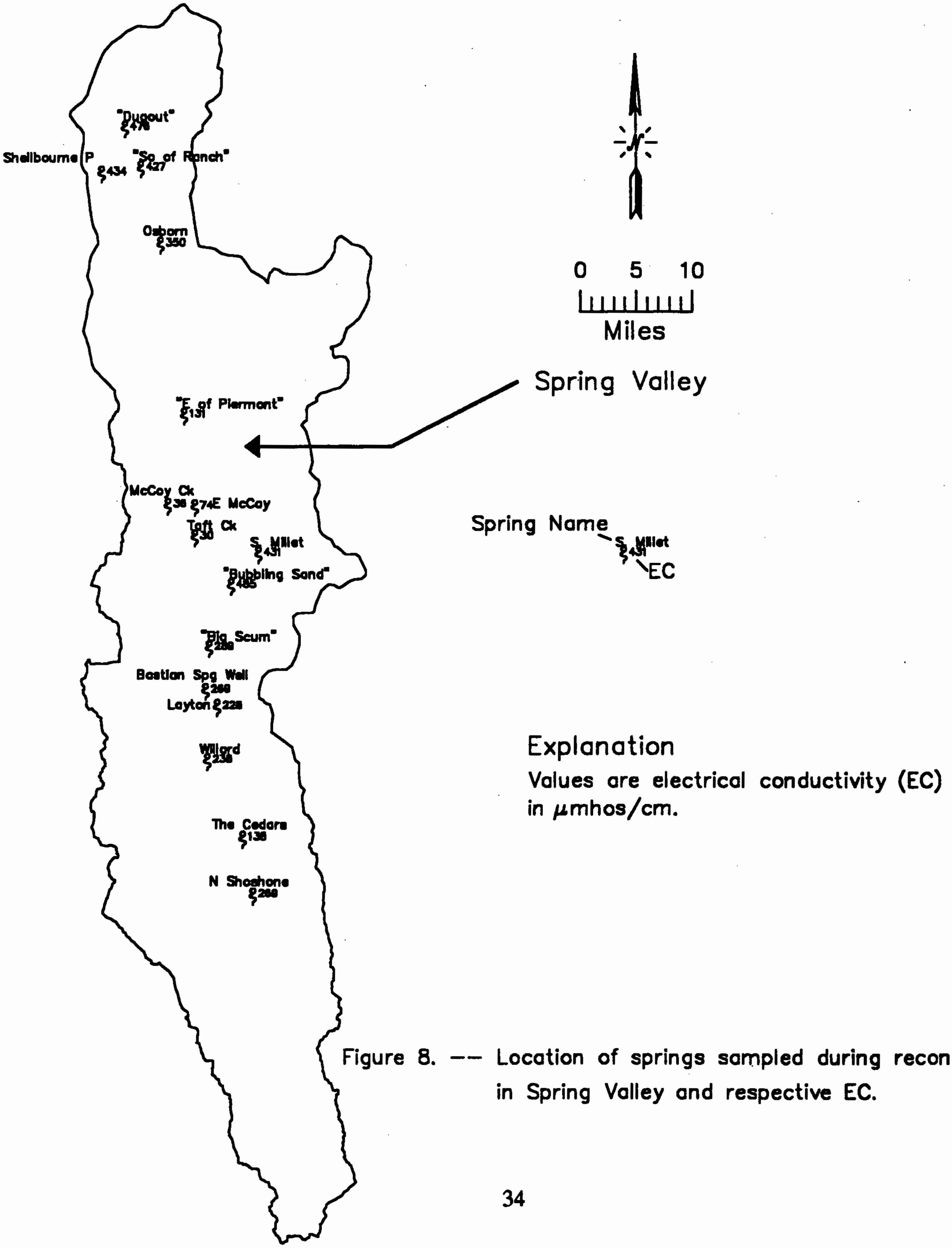


Figure 8. -- Location of springs sampled during reconnaissance in Spring Valley and respective EC.

Table 6.--Stable and radioactive isotope data from select springs and streams in Spring Valley.

Sample ID	$\delta^{13}C$ ‰	^{14}C		Tritium	$\delta^{18}O$ ‰	$\delta^{2}D$ ‰
	PDB	PMC	age *	pCi/l	VSMOW	VSMOW
McCoy Ck	na	na	na	72+/-9	-16.0	-118
Piermont Ck	na	na	na	53+/-8	-15.7	-116
S. Bastian Sp	-8.0	34.7	8510+/-100	<10	-16.2	-121
N. Shoshone Sp	-9.3	46.8	6110+/-85	23+/-7	-15.1	-111
The Cedars Sp	-11.1	49.5	5645+/-165	<10	-14.6	-108
E. Piermont Sp	-13.7	na	na	?	-16.1	-121
S. Millick Sp	-10.3	56.8	4550+/-75	?	-15.2	-116

PDB=Pee Dee Formation Belemnites PMC=Percent modern carbon
VSMOW=Vienna Standard Mean Ocean Water * ^{14}C age dates are ^{13}C corrected.

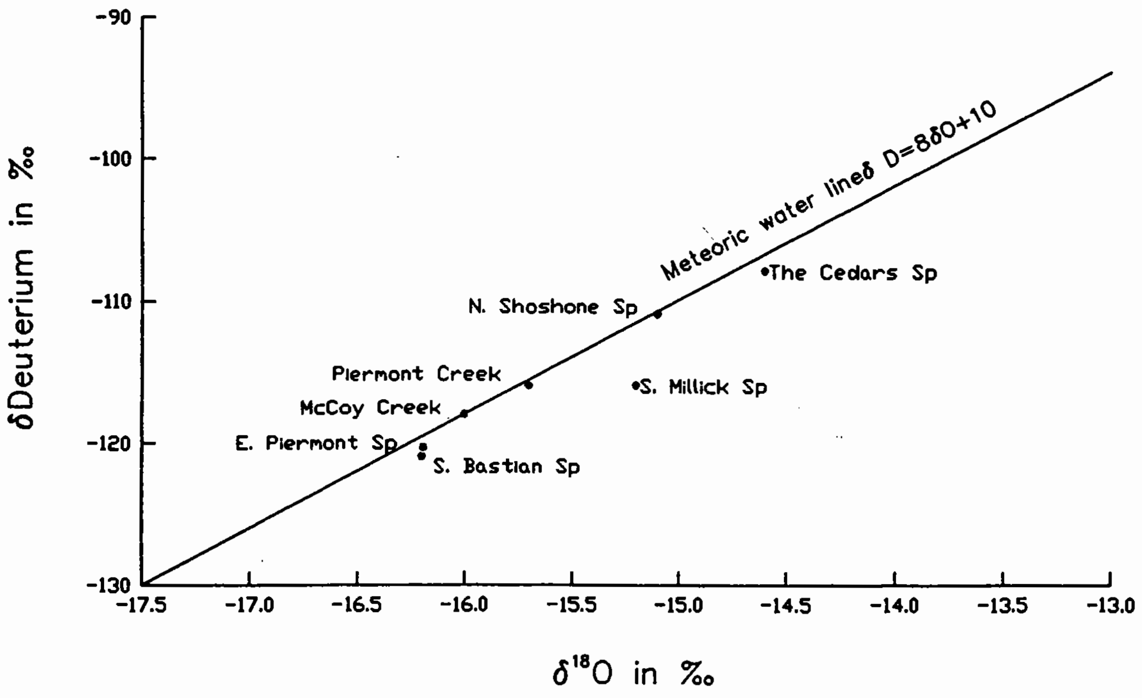


Figure 9.--Plot of δDeuterium versus $\delta^{18}O$ of select water samples from Spring Valley. Meteoric water line after Craig, 1961.

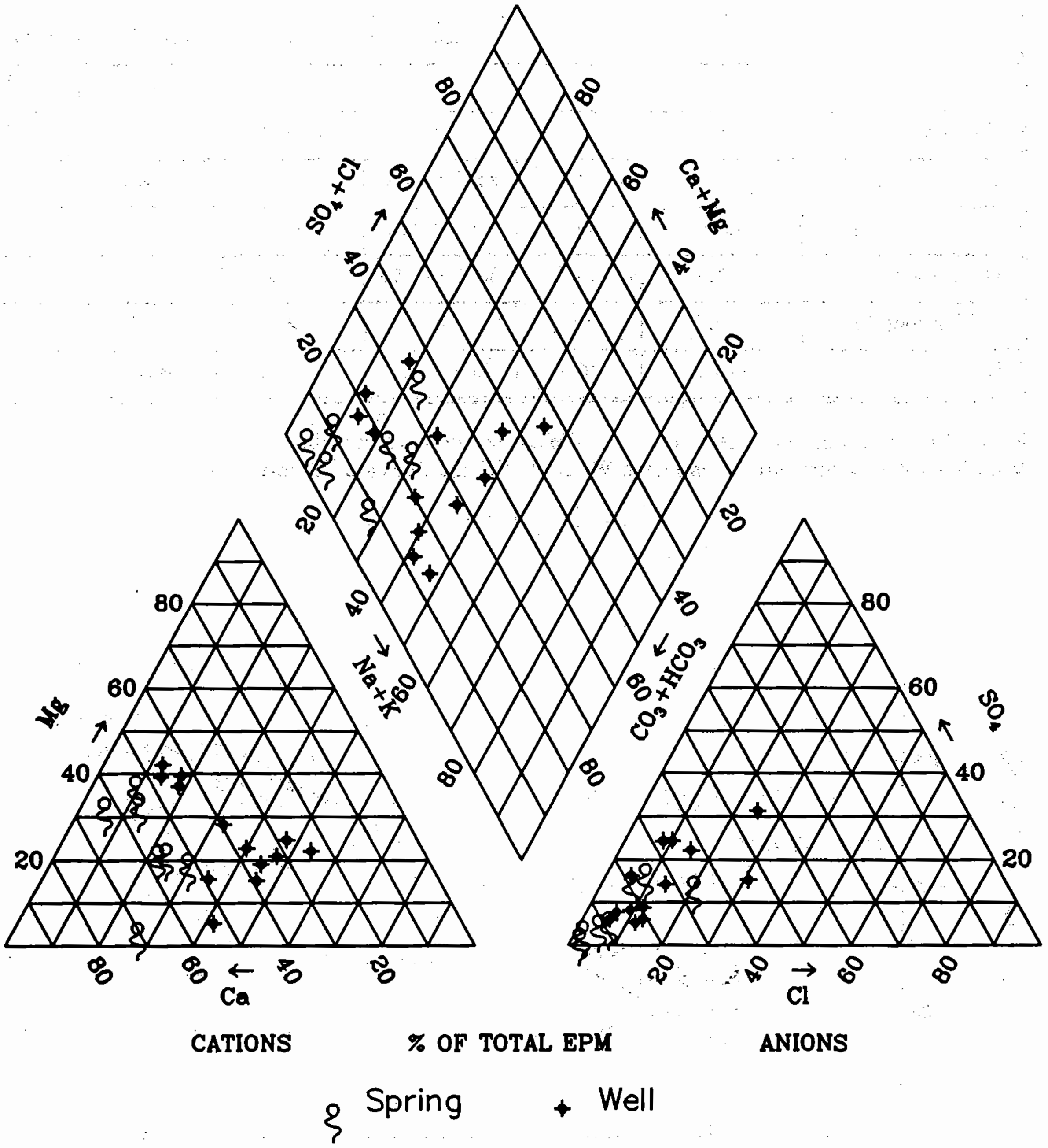


Figure 10.--Trilinear plot of select spring and well samples from Spring Valley.

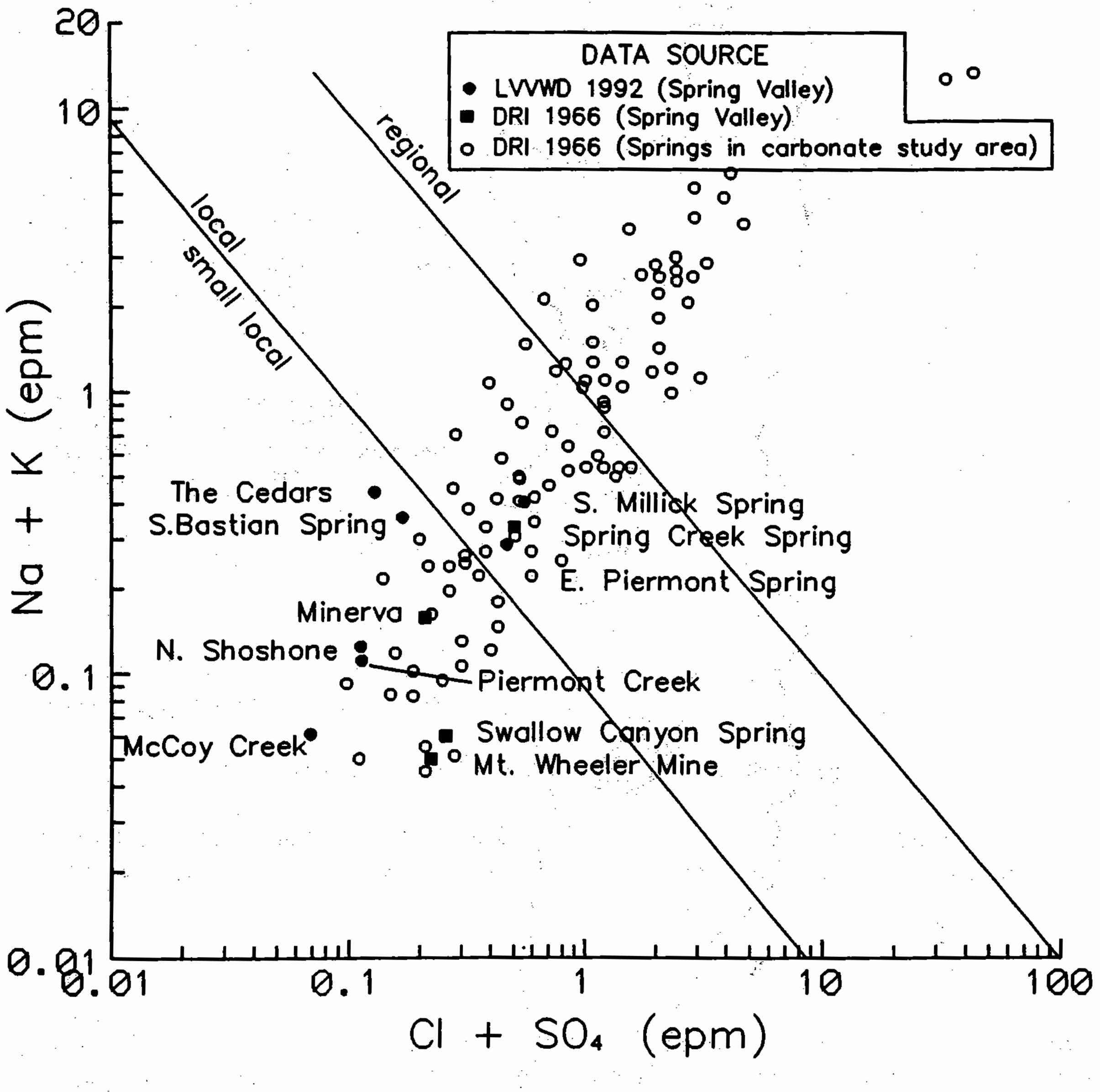


Figure 11.--Plot of the relationship between water chemistry and spring classification (modified after Mifflin, 1968.)

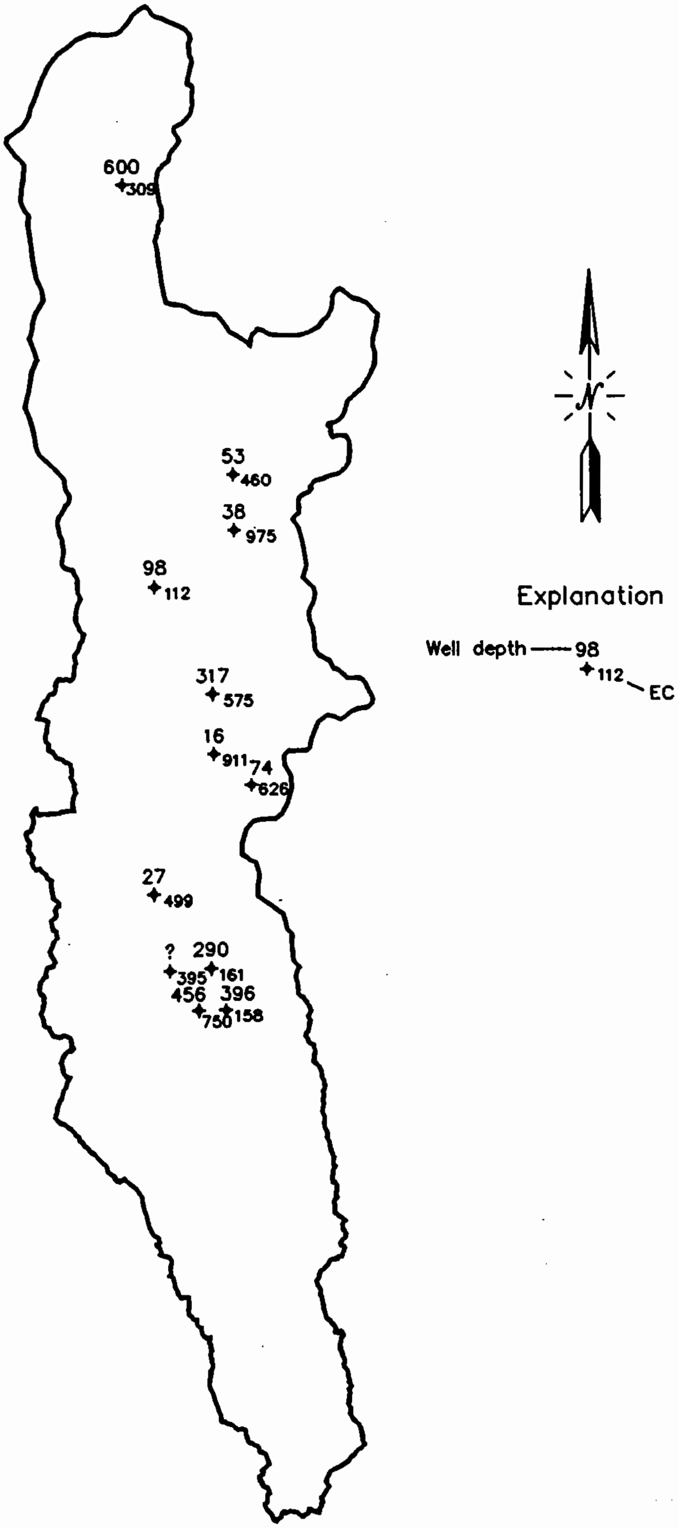


Figure 12.--Location of select wells and corresponding EC and depth in Spring Valley.

Water Resources Budget

A water resources budget consists of a complete accounting of all components of inflow and outflow for a hydrographic basin. The results of any model developed to simulate flow in a basin are dependent upon the accuracy of the budget. Table 7 summarizes the water budgets for Spring Valley. The following sections present the current estimates for recharge and discharge for Spring Valley.

Table 7.--Water resources budget for Spring Valley.

		Acre-feet/year (rounded)
INFLOW		
Precipitation Ground-Water Component		75,000
Subsurface Inflow (from Tippet Valley)		2,000
Precipitation Surface-Water Component1)		35,000
	TOTAL	112,000
OUTFLOW		
Evapotranspiration (phreatophytes)		70,000
Agriculture (crop transpiration)1)		21,000
Outflow (to Hamlin Valley)		4,000
Other loss (mining, domestic, stock)		2,000
Surface water loss through evaporation (by difference)		15,000
	TOTAL	112,000

Source: Rush and Kazmi (1965), Scott et al. (1971), Summit Engineering Corp.

1) not included in steady state model

Estimated Average Annual Ground-Water Recharge

Recharge to the Spring Valley Basin consists of three components: precipitation, subsurface inflow, and secondary recharge. Estimates for these elements are provided in the following sections.

Precipitation

The source of recharge to the hydrologic system of Spring Valley is the infiltration of precipitation over the basin. No meteorological stations are located in Spring Valley and the characterization of precipitation over the area is inferred from recording stations located in adjacent valleys. The total precipitation over Spring Valley is estimated at 960,000 acre-feet per year (Scott, et al., 1971). The volume of ground-water recharge derived from precipitation is reported by Rush and Kazmi (1965) to be 75,000 acre-feet per year, or less than 8 percent of the precipitation.

The infiltration of precipitation does not occur evenly over a large area. Rather, as determined by Eakin et al. (1951) and Quiring (1965), the distribution of precipitation, and hence, infiltration and recharge, in the desert valleys of Nevada, is primarily a function of elevation and latitude. Thus, for the purposes of developing a ground-water flow model of Spring Valley, recharge totalling about 75,000 acre-feet per year may be distributed according to the zones summarized in Table 8.

Table 8.--Recharge distribution zones for Spring Valley (Rush and Kazmi, 1965).

ELEVATION Feet Above Sea Level	PRECIPITATION Inches/Year	APPROX. AREA Acres	PRECIPITATION Acre-feet/year	RECHARGE RATE Percentage	RECHARGE FLUX acre-feet/year (rounded)
>9,000	>20	59,100	103,000	25	26,000
8,000-9,000	15-20	107,300	156,000	15	23,000
7,000-8,000	12-15	183,500	206,000	7	14,000
6,000-7,000	8-12	393,000	326,000	3	10,000
<6,000	<8	342,000	171,000	0	0
TOTALS (rounded)			960,000		75,000

There is some question concerning the accuracy of recharge rates based upon this methodology. As noted by Watson et al. (1976), the Maxey-Eakin method is simply a first approximation which, in lieu of basin-specific data, provides a method for making gross estimates of recharge. This methodology, while appropriate for reconnaissance level investigations, may have significant error when applied to any given basin. However, Avon and Durbin (1994) concluded the method is a fairly good indicator and is probably more accurate than portrayed by Watson et al. (1976). Nevertheless, in water-rich valleys such as Spring Valley, the shallow depths to water and extensive surface water regime suggest that the application of the Maxey-Eakin method may underestimate the percentage of recharge. The amount of surface water infiltrating into the ground-water system from the stream channels past the bedrock-alluvium contact is unknown. The 35,000 acre-feet per year surface water component (listed in Table 7) is estimated at the bedrock alluvial contact.

Subsurface Inflow

As noted previously, the inflow of ground water to Spring Valley from upgradient basins is limited to only about 2000 acre feet per year contributed from Tippett Valley. The hydrogeologic data that are available indicate that there are likely hydraulic divides between Spring Valley and Tippett Valley on the northeast and Lake Valley on the southwest. Because of these divides it is considered likely that flow from the Tippett Valley is limited to deep underflow and no inflow from Lake Valley is occurring.

Secondary Recharge

Secondary recharge is usually estimated based on the type of usage of the ground water and surface water. In many basins in Nevada, secondary recharge is minor. This is not the case for Spring Valley. Because of the ample quantities of surface water flow that are diverted and that is used for irrigation and lessor amounts of ground water, an appreciable quantity of artificially induced secondary recharge is believed to be occurring in the basin.

There is also a large component of naturally occurring secondary recharge in the basin. Rush and Kazmi (1965) referred to the runoff that reaches the lowland areas of Spring Valley as rejected recharge and noted that although it is a critical element of the water budget, it could not be estimated. However, secondary recharge of water "rejected" in upland areas could be appreciable and a significant part of the overall water budget for the basin.

Currently (1990), the water use within Spring Valley is primarily for irrigation with lesser quantities withdrawn for mining, livestock watering, and domestic use. A total of about 6,900 acres of land are under cultivation. Most of the demand for irrigation is supplied by surface water. Assuming an overall application rate of 4 feet per year and a consumptive use rate of 75 percent (3 feet), then the secondary recharge over irrigated areas may be estimated at about 6,900 acre-feet per year. Consumptive use (agricultural ET) is estimated at about 12,500 acre feet per year of surface water and about 8000 acre-feet per year of ground water. Surface-water use is assumed (Rush and Kazmi, 1965) to be 60 percent while ground water provides about 40 percent of water for irrigation.

Because of the seasonal nature of streamflow and precipitation, water ponds over a large area of Spring Valley. If the underlying sediments are unsaturated then this ponded water contributes secondary recharge to the ground-water system. Streambed infiltration and leakage from canals is probably also contributing to secondary recharge, but the amount is unknown.

Based on the above, secondary recharge is providing some amount of ground-water recharge. However, when evaluating the role of secondary recharge in the steady state hydrologic model and the overall basin budget the following must be considered. For valleys such as Spring Valley, where there is a significant surface component, it is difficult to separate the ground-water component from the surface-water component.

Table 7 listed the water resources budget for Spring Valley, estimating a ground-water recharge component based on the Maxey Eakin method (Eakin, et al., 1951), a subsurface ground-water inflow component based on Harrill et al. (1988), and an estimate of the surface water component at the bedrock-alluvial contact. This estimate was arrived at based on spot measurements of the major streams during July 1964 which arrived at a mean flow of 50 cfs and confirmed by measurements made in July 1991 which totaled a mean flow of 48.9 cfs. These measurements are discussed previously under the Surface Water section of this report. As stated in this section, the mean discharge for July at Cleve Creek (the only gaged stream) is close to the mean annual discharge rate. If this is assumed for all the major streams the annual discharge is about 35,000 acre-feet per year at the bedrock alluvial contact (the gage at Cleve is near this contact). This number is probably larger since it does not account for all streams or washes, just the major ones that have been measured. Rush and Kazmi (1965) estimated a rejected recharge component of 90,000 which was a combination of surface water and ground water. Because water does pond on the playas and is lost to evaporation, the 35,000 acre-feet per year is probably low.

If the assumption is made that the Maxey-Eakin method (Eakin, et al., 1951) only applies to recharge to the ground-water system occurring in the mountain block, as is the case in the central to southern Nevada basins used to derive the method, then any recharge to the ground-water system from surface water below the mountain block is not considered in the Maxey-Eakin method. This makes the Maxey-Eakin method for estimating ground-water recharge in valleys such as Spring Valley with significant surface-water components extremely conservative.

It is this surface water that is primarily diverted for irrigation, therefore manmade diversions probably result in aiding recharge to the ground water system, since 25% is assumed to enter the ground-water system and 75% is assumed to ET from crops. Prior to man-made diversions, some fraction recharged the ground-water system and the remaining surface water flowed to the playa and evaporated. Because of the shallow ground-water table in this area, the component reaching the ground-water system was also evaporated or transpired.

Therefore the steady state modelling effort only considers the ground-water component as defined by the Maxey-Eakin method and ET from phreatophytes, as defined by Rush and Kazmi (1965). Secondary recharge and evapotranspiration from agriculture is considered to be within the conservative error of the system recharge estimate and probably has not markedly changed the steady state hydrologic budget anyway.

Estimated Average Annual Discharge

Components of discharge include evapotranspiration, which includes spring flow, well pumpage, and subsurface outflow. Estimates of the quantity of these components are included in the following sections.

Evapotranspiration

Because of the shallow depth to the water table over much of Spring Valley, evapotranspiration (ET) is the major source of ground-water discharge. ET includes the consumptive use of water by phreatophytes and evaporation from bare soil. Rush and Kazmi (1965) reported that ET in the lowland areas of Spring Valley is on the order of 70,000 acre-feet per year. ET rates and acreages used to calculate 70,000 acre-feet per year are shown in Table 9. Minor ET may occur in upland areas where perched ground water may be present and in the areas immediately downgradient of discharging springs.

There is published information that suggests that the Rush and Kazmi (1965) estimate of ET is low, and may be significantly low. For example, in developing their estimate of water use by greasewood and rabbitbrush, these authors assumed a probable average ET rate of 0.2 acre-feet per acre per year and estimated total ET for this vegetative cover at 28,000 acre-feet per year. Robinson (1970) however in a controlled experiment, measured average ET by greasewood at

1.4 acre-feet per acre (of which 0.7 acre-feet per acre was ground-water consumption) and by rabbitbrush at 1.65 acre-feet per acre (of which 1.06 acre-feet per acre was ground-water consumption). Nichols (1992) found phreatophyte transpiration might be up to 3.5 times as high as those used by the USGS reconnaissance studies for northern and eastern Nevada. Applying factors reported by Nichols as shown in Table 9, the evapotranspiration in Spring Valley could be as high as about 140,000 acre feet per year.

Table 9.--Estimated annual natural ground-water discharge by evapotranspiration in Spring Valley.

Means of Ground-Water Discharge	Depth to Water (ft)	Area (acres)	Average Areal Density (%)	Average[1] Use Rate (ft/yr)	Discharge (ac.ft.)	Average[2] Use Rate (ft/yr)	Discharge (ac.ft.)
Wet meadow and salt grass	0 - 5	14,600	50	1.5	22,000	—	(22,000)[1]
Saltgrass, rabbitbrush and moderately wet meadow	0 - 10	13,200	30	1.0	13,000	—	(13,000)[1]
Greasewood, saltgrass, meadowgrass	5 - 15	7,100	30	.5	3,600	.8	5,700
Greasewood and rabbitbrush	10 - 50	139,000	15	.2	28,000	.7	97,000
Bare soil and sparse vegetation	5 - 15	11,600	—	.1	1,200	—	(1,200)[1]
Totals (rounded)		186,000			70,000	—	140,000[3]

1) Based on Hood and Rush (1965)
2) Based on Nichols (1992)
3) Rounded

Springs

As its name implies, one of the most striking hydrologic features of Spring Valley is the presence of hundreds of springs and seeps. The many springs sustain an appreciable baseflow for creeks in the mountains and valley. As noted previously, many of these springs occur in distinct spring lines that appear to be the result of geologic controls on ground-water flow.

Given the number of springs within the basin, records on spring discharge are quite scant. Rush and Kazmi (1965) could only characterize the spring discharge as "considerable". For Cleve Creek, the base flow of about 5 cfs is supported by springs and represents one-half of the average discharge rate of 10.2 cfs. If a similar relationship occurs between base and peak flows at other gaging stations, then the discharge of springs feeding gaged streams is about 18,000 acre-feet per year. The discharge of springs to ungaged reaches of streams cannot be estimated but could be significant.

Water Wells

Based on information provided by SEC, there are more than 250 surface water and ground-water rights or applications for Spring Valley. The largest single users of ground-water are the agriculture and mining sectors.

With about 6,900 acres under irrigation, and assuming a consumptive rate of 3 acre-feet per acre, then total water used for agriculture is estimated at about 21,000 acre-feet per year. If one assumes that 40 percent is supplied by ground water, this equals to about 8,000 acre-feet per year of ground water lost due to crop consumption.

Other ground-water use sectors include mining, stock watering, quasi-municipal use, and recreation. Considering these permitted ground-water rights of about 2000 acre-feet with the 8000 acre-feet of estimate agriculture consumption ground-water pumpage is estimated at 10,000 acre-feet per year.

Outflow

Discharge through subsurface flow from the Spring Valley is to the southeast into Hamlin Valley. Rush and Kazmi (1965) estimated that about 4000 acre-feet per year of ground water discharge into Snake Valley from Spring Valley through Hamlin Valley. As discussed previously, this estimate agrees well with the expected ranges of transmissivities present, the observed flow path width and the measured hydraulic gradient between the two basins.

Total Discharge

As discussed above the total discharge from Spring Valley is difficult to quantify. The evapotranspiration from the phreatophytes are estimated at 70,000 acre-feet per year (Rush and Kazmi, 1965). Ground-water underflow is estimated to be about 4000 acre-feet per year. Currently (1990) transpiration from crops is estimated to be about 21,000 acre-feet per year. The volume of surface water lost through evaporation is not quantified. About 2000 acre-feet per year is estimated to be lost from other activities such as mining, stock watering, and domestic uses.

Perennial Yield

Scott, et al. (1971) define perennial yield as "the maximum amount of natural discharge that can be salvaged each year over the long term without depleting the ground water reservoir." The perennial yield of Spring Valley is reported to be 100,000 acre-feet per year by Scott et al. (1971). This value, as developed originally by Rush and Kazmi (1965), includes the salvage of one-third of the rejected recharge.

Storage

The quantity of ground water stored in the geologic units underlying Spring Valley is large; the amount of recoverable ground water in storage in the valley reservoir is estimated to average about 10 percent of the volume of the saturated valley-fill (Scott, et al., 1971). For Spring Valley, Rush and Kazmi (1965) estimated the quantity of recoverable ground water in the saturated valley fill to be 4.2 million acre-feet in the upper 100 feet.

No estimates have been made of the amount of ground water that is stored in the carbonate aquifer in Spring Valley. Although the storage capacity of the carbonates is believed to be less than that of the valley-fill, the larger saturated thickness and greater areal extent of the carbonate aquifer suggests that the quantity of recoverable water from storage may be even greater than that expected from the valley-fill deposits.

Dettinger (1989) reported that the quantities of ground water in the regional carbonate aquifer are "enormous", and estimated that the total quantity of water stored in this regional aquifer south of Pioche and Tonopah is on the order of 800 million acre-ft. Adopting Dettinger's assumption of a total of one percent of the aquifer volume as being recoverable, then a rough estimate of the recoverable ground water in storage in Spring Valley can be made. Based upon this recovery factor, the areal extent of the carbonates underlying the valley (approximately 1,300 square miles and excluding the Cambrian clastic aquitard), and an assumed saturated thickness of 2000 feet (about the limit for economic well drilling), then the total recoverable ground-water storage in Spring Valley is estimated to be approximately 16 million acre-feet. However, the upper 100 feet of the rock aquifer probably contains about 800,000 acre-feet of recoverable ground-water.

INVENTORY OF WATER RIGHTS, PUMPAGE, AND LAND USE

An estimate of ground-water usage in a basin can be obtained from present water rights, pumpage, and application of pumped water to crops and other uses. These factors are examined in the following sections.

Present Development

The level of development of water resources in a basin can be illustrated by the water right allocations and the current ground-water pumpage within that basin. In Spring Valley, agricultural development is present, with 6900 acres under irrigation. It is conservatively estimated that about 60 percent of the water used to support agriculture is derived from surface water sources. Mining and industrial users account for the second largest water use sector in the valley. The Nevada State Engineer has, however, allocated water-right permits in the basin and applications have been made for additional appropriations that are senior to the District's applications.

Water Right Status

Based on information supplied by SEC contained in Appendix B, the State Engineer has allocated water-right permits in Spring Valley for both surface water and ground water totalling about 73,600 acre feet. Of this total about 18,000 acre feet per year represent ground-water rights and 55,600 acre feet per year represent surface water rights based on consumptive use as listed in Table 10.

Table 10.- Existing permits and applications (consumptive use) in Spring Valley (acre-feet per year).[1]

	Permits		Applications	
	Surface	Underground	Surface	Underground
Irrigation/Domestic	53,600	15,800	28,500	29,000
Mining/Industrial	1,600	1,800		
Stock	400	400		
Totals	55,600	18,000	28,500	29,000
1) Excluding Desert Land Entries				

Pumpage

Data on actual water use in Spring Valley are not available. It is assumed that the total pumping is about 10,000 acre-feet per year, based upon an assumed consumptive use as discussed previously under wells.

Land Use

Most of the land in Spring Valley is public-domain land administered by the Bureau of Land Management. Some areas are used for livestock range and there are about 6900 acres conservatively estimated under irrigation.

Future Development

Plans for future development of Spring Valley are unknown. As Table 10 shows, there are about 28,500 acre-feet of consumptive surface water applications preceding the District's filings. The majority of these are for irrigation rights. However, there are currently permits for 53,600 consumptive acre-feet which would support about 18,000 acres. For 1990 it was estimated about 6,900 acres were under irrigation. This is an extremely conservative estimate which considered acreage that appeared it had not been irrigated for some time. Landsat Thematic Mapper (TM) satellite data was analyzed (June 1990 scene) for land under active irrigation. This analysis showed that about 4,500 acre-feet were under active irrigation with about 1,000 acres irrigated within the past few years. It appears, based on Rush and Kazmi (1965) estimation of 8,700 acres under irrigation in 1964, that overall agriculture is declining.

Of the 29,000 acre-feet of consumptive ground water right application preceding the Districts, one application is for 26,000 acre-feet for industrial use. This application was filed for the White Pine Power Project by Los Angeles Water and Power in Los Angeles, California. Of the existing 15,800 acres of consumptive ground water permitted, it is conservatively estimated that about 10,000 acre-feet per year are actually used.

MODEL DEVELOPMENT

MODFLOW is a three dimensional ground-water flow model that simulates ground-water movement through gridded layered cell blocks by solving a series of finite difference equations. These equations preserve the quantity of ground water in the modelled area. For any further detail regarding the flow model, the MODFLOW documentation (McDonald and Harbaugh, 1988) should be consulted.

The first step in developing a ground-water flow model is the formulation of a conceptual hydrogeologic model of the area to be mathematically represented. This conceptual model is based upon the available hydrologic data, inferences based on observations of similar hydrologic settings, and assumed conditions or expected ranges of conditions for parameters that have not been measured or are not readily estimated for the subject hydrologic basin.

The first step in the mathematical representation of the conceptual model is the development of a grid system covering the hydrologic basin. The grid system can be either single or multiple layers with each cell in the model being identified by grid row, column, and layer designation. Usually the grid size and number of layers are chosen based on the amount of available hydrologic data for the particular basin. Each cell is given a number of parameters (i.e. transmissivity, storage (in transient scenarios), conductive characteristics for spring flow, recharge where appropriate, and rates of evapotranspiration when the water levels are within a set distance from land surface) which control water flow through the model. The District made the decision to make all the grids for the individual ground-water flow models one mile by one mile and each model two layers, one to represent the alluvial system and the other the consolidated bedrock. In some valleys there were not enough data to warrant this scale; however, preparation of the model on this scale will provide a framework for future data entry resulting in model refinement.

Approach and Assumptions

The approach taken in all the individual basin models was to produce a steady state model which replicated as closely as possible the hydrologic basin budget as defined by the USGS while attempting to match existing ground-water levels. The most important "constant" becomes the amount of water entering the system or the recharge and of course water levels which serve as calibration points. Rush and Kazmi (1965) established the hydrologic budget for Spring Valley. As discussed previously, there are data for over 120 wells in Spring Valley which provides a good areal data base for model calibration, however there are no known wells completed in consolidated rock.

A one square mile grid, 113 rows by 26 columns as shown in Figure 13, consisting of two layers, was constructed to simulate ground-water flow in Spring Valley. Both the upper alluvial fill and surrounding consolidated rock outcroppings and the lower consolidated rocks were modelled as confined fixed transmissivity units. Parameter selection (i.e. transmissivity and vertical leakance) was keyed to rock type. Figure 14 shows the lithology distribution for the

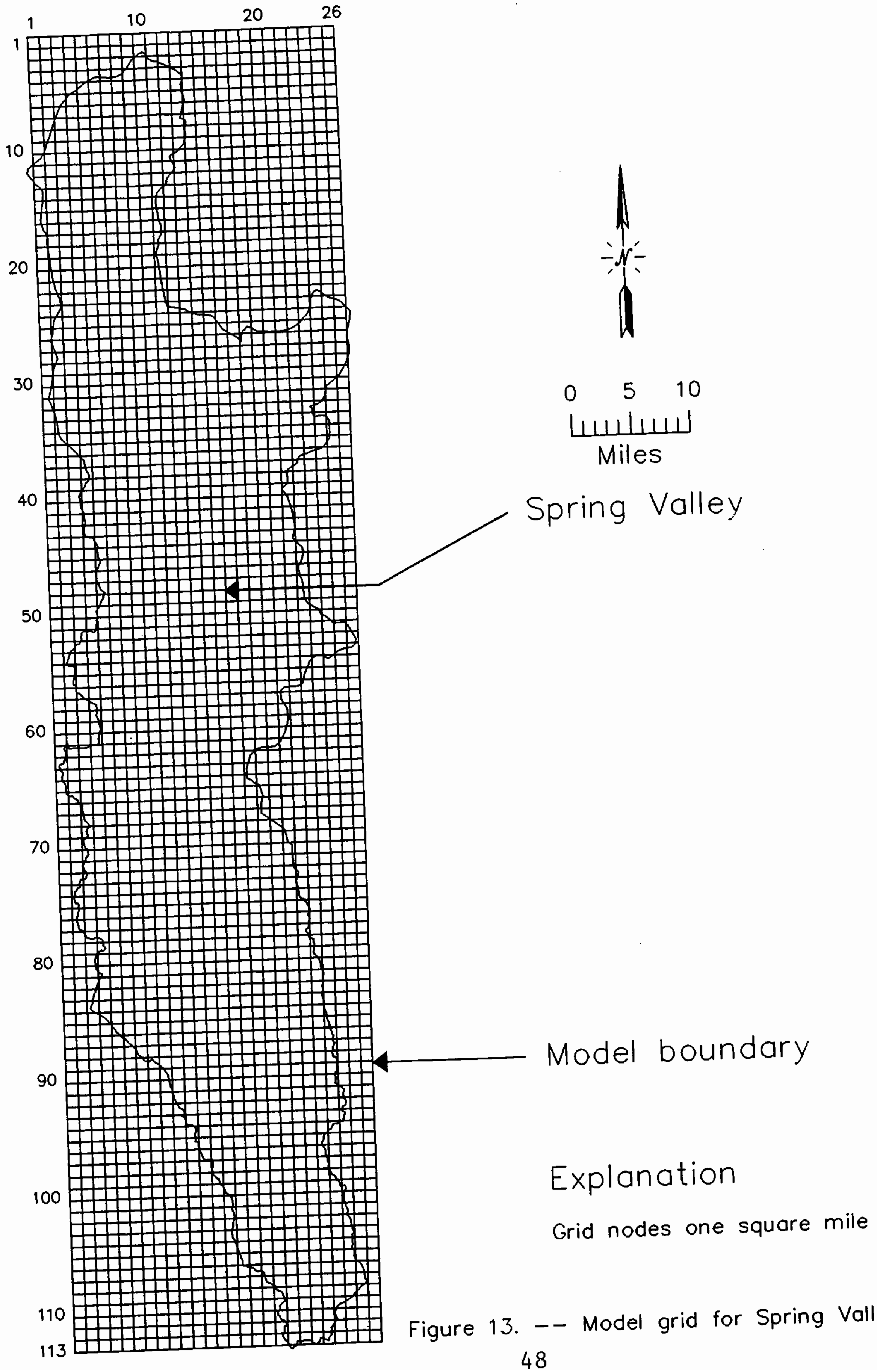
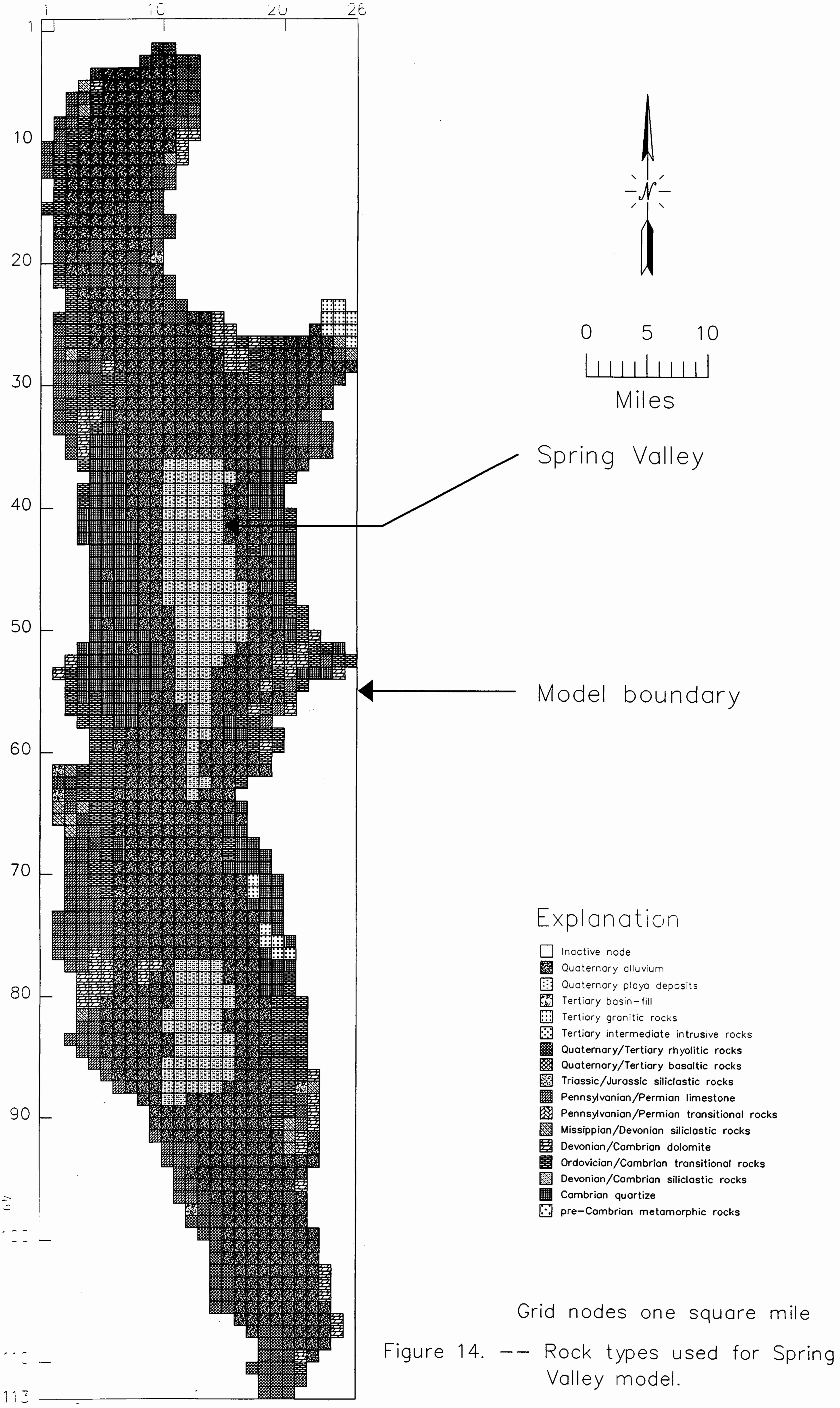


Figure 13. -- Model grid for Spring Valley.



Grid nodes one square mile

Figure 14. -- Rock types used for Spring Valley model.

upper layer, specifying alluvium and rock type based on the digital representation of the Nevada 1:500,000 scale geology map (Stewart and Carlson, 1978) prepared by Turner and Bawiec (1992). The lower layer or underlying consolidated rocks were assumed to be carbonates with some overlying volcanics which were simulated by using the vertical conductance between layers.

Parameter Estimates

Recharge and Discharge

Rush and Kazmi (1965) estimate the recharge, based on the method described by Eakin et al. (1951), to Spring Valley to be about 75,000 acre-feet per year. Rush and Kazmi (1965) also estimated the total ground-water discharge from evapotranspiration to be about 70,000 acre-feet per year. The amount of ground water used in Spring Valley was estimated by Rush and Kazmi (1965) to be that necessary to irrigate about 40 percent of the total 8,700 acres under irrigation in 1964, with surface water being used for the majority of irrigation. If one assumes a consumptive use of 3 feet per acre, this equates to about 10,000 acre-feet per year of ground-water use for irrigation in 1964. A recent assessment of land use and water rights permits in these valleys confirmed that well pumpage for irrigation probably declined in the past thirty years as has the total irrigated acreage and is estimated to be about 8000 acre-feet per year. Also, it is estimated that another 2000 acre-feet per year is used for mining, domestic, and stock watering, for a total ground-water pumpage of 10,000 acre-feet per year.

Primary Recharge

Primary recharge in Spring Valley occurs from the infiltration of precipitation into the ground-water system occurring in the higher elevations as well as from some infiltration of surface water runoff and spring flow. Spring Valley receives a large part of its recharge from the Schell Creek Range bordering the valley on the west side. Other ranges contributing to Spring Valley recharge are the Snake and the Wilson Creek Ranges on the east side of the valley.

Digital elevation data were used to computer generate and distribute recharge based on the Maxey-Eakin method (Eakin et al., 1951) with the factors listed for Spring Valley in the report by Rush and Kazmi (1965) and shown in Table 8. Digital elevations were obtained for the complete Cooperative Water Project (CWP) area from the USGS, which are based on the 1:250,000 scale Army Map Series (AMS) maps and contain an elevation every 90 meters. This data was smoothed by finding the nearest neighbor then resampling at 150 meter intervals. The file was then subset for the Spring Valley grid area. It should be noted that even after smoothing the digital elevations, there were areas that had erroneous elevation values, values lower than the water table. A depth to water map was made that showed potential areas where there could be elevation busts. Near the valley axis in the central to northern part of Spring Valley, the water table is very near land surface and artesian in some areas. The accuracy of the digital elevations, since their source is the 1:250,000 scale AMS maps with 100 feet supplemental contours is about 50 feet; therefore, an elevation error of just a few feet can result in water levels above land surface.

Based on the depth to water map, areas where water was above land surface were compared to the USGS 1:100,000 scale maps. In areas where there were elevation errors in the DEMs, these values were replaced with values interpolated from the 1:100,000 scale maps.

Dr. James Tracy developed a program to calculate recharge based on these digital elevations for each grid cell using the Eakin factors (precipitation and percentage infiltrating the ground-water system) listed in the various USGS reconnaissance reports. The product of the program is a matrix corresponding to the grid which specifies recharge rates for each cell. This program was used to generate such a matrix for the Spring Valley area.

Figure 15 is a graphical representation of the recharge distribution used in the Snake and Hamlin Valley model. Based on this method, the recharge for Spring Valley was calculated to be about 72,000 acre-feet per year, which was what was calculated by Rush and Kazmi (1965) but they rounded the number to 75,000 acre-feet per year.

Secondary Recharge

Secondary recharge is due to infiltration of water from anthropogenic uses such as irrigation or septic disposal systems. As stated above, secondary recharge from irrigation was estimated to be about 7000 acre-feet per year based on a 25% return to the ground-water system (a combination of both surface and ground water) in Spring Valley. The majority of this (estimated to be 60%) is from surface water. Ground water is used only to supplement surface water in most cases. The transient runs that will be simulated as part of the District's regional model will include pumpage based on land use. As discussed previously in the report, this secondary recharge is not thought to be significant in terms of the steady state budget and was not included in the steady state model.

Discharge

Evapotranspiration

Evapotranspiration (ET) was simulated in Spring Valley by using the MODFLOW ET module. Maximum rates and extinction depths are specified and ET is calculated linearly, based on depth to water, with zero ET at the specified extinction depth and maximum ET occurring when the water table is at land surface.

Rush and Kazmi (1965) estimate ET in Spring Valley for five different types of phreatophytic zones based on types of phreatophytes and depths to water and one zone for bare soil with sparse vegetation, these are shown in Table 9. To incorporate these zones in the model, the map delineating these zones was digitized and using the ARC Info gridding function a matrix was established specifying a certain number for a specific zone corresponding to the appropriate grid row and column. Figure 16 shows the resulting zones, final rates and extinction depths used in the model.

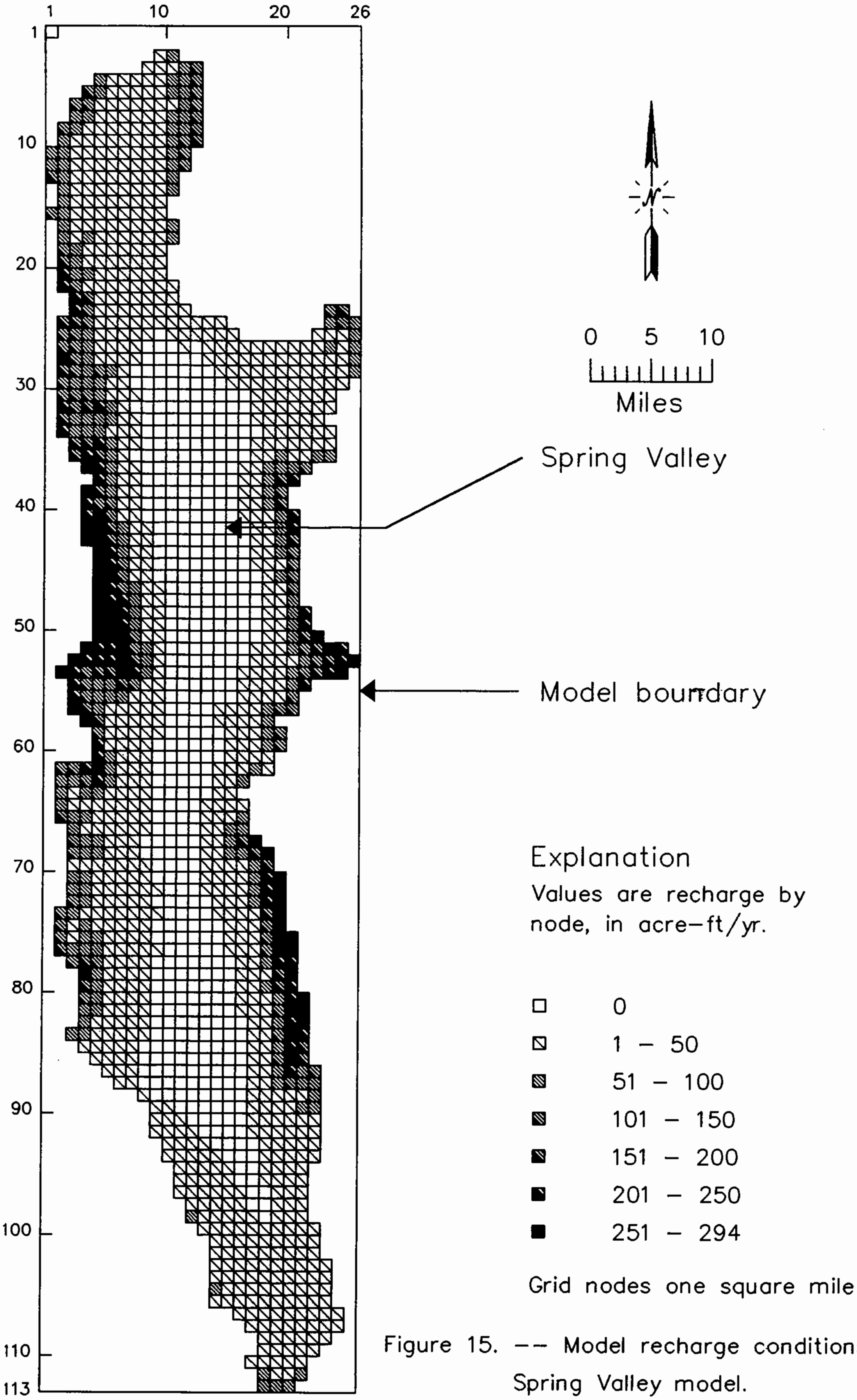
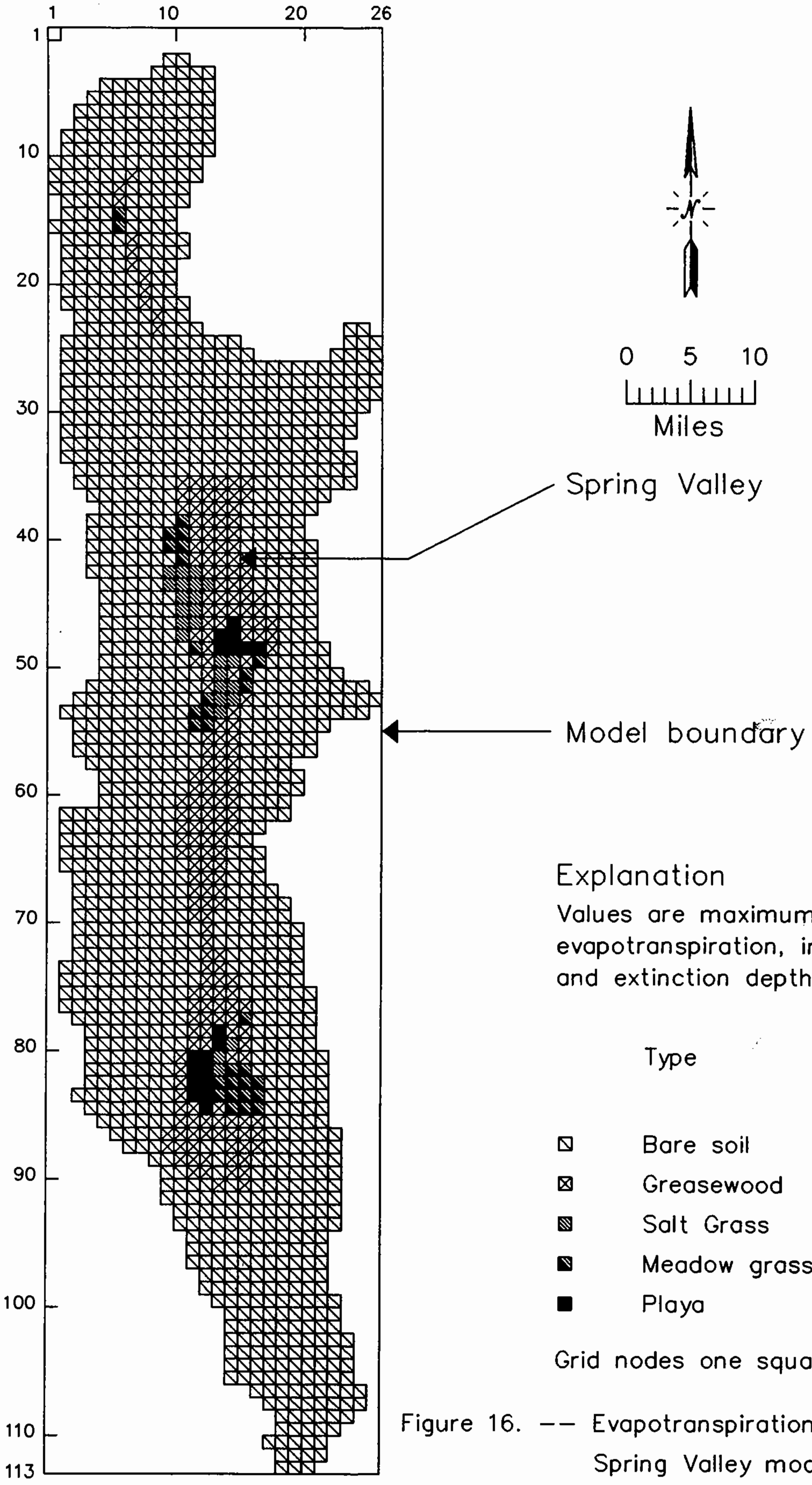


Figure 15. -- Model recharge conditions for Spring Valley model.



Explanation

Values are maximum rates of evapotranspiration, in feet/year and extinction depths, in feet.

	Type	Rate	Extinction Depth
⧅	Bare soil	0.36	15
⊠	Greasewood	0.73	50
▨	Salt Grass	1.82	10
▩	Meadow grass	4.00	5
■	Playa	0.36	15

Grid nodes one square mile

Figure 16. -- Evapotranspiration values used, for Spring Valley model.

Because the rates assumed by Rush and Kazmi (1965) were constant for each zone regardless of the actual variable depth to water, greater potential ET rates had to be specified in the ET module to arrive at volumes specified by Rush and Kazmi (1965). Initially, extinction depths specified in Rush and Kazmi (1965) were used with rates twice those listed to compensate for the overall rate regardless of depth to water, as shown in this report in Table 9. Therefore, when the model simulated depth to water was one half the listed depth to water range or extinction depth specified by Rush and Kazmi (1965), the rate was equal to that listed in Rush and Kazmi (1965). These rates resulted in insufficient ET causing water levels to be higher than land surface. Finally, rates two to four times as great as that specified in Rush and Kazmi (1965) with the same extinction depths, with one exception discussed below, were used in the ET module and produced a total ET of about 70,000 acre-feet per year. The one exception is that the extinction depth of 50 feet was used for both designations of greasewood and also one maximum rate of 0.73 ft per year was used. The percentages of ET occurring in each zone are near the USGS designations with that for greasewood being slightly higher (54% compared to 45%) which was compensated for with the salt grass rates being slightly lower (9% compared to 19%).

Springs

Springs are found throughout Spring Valley, on alluvial fans on both sides of the valley, in the middle of the valley and in the surrounding mountain blocks. There are, however, two main spring areas; in the northern part of the valley most of the springs are on the west side, and in the southern part the springs are generally on the east side. The flows of the numerous high altitude springs in the mountain block join the snowmelt and become part of the surface runoff.

Most of the springs are classified as gravitational cold water springs, but there is thermal water in the southern part of the valley in the area called the Cedars. In this area there are several flowing wells that provide about 21 degrees C water to a series of ponds. However, there are no known regional thermal springs in Spring Valley.

Spring flow data is scarce. Some recent water quality and flow data were reported in the "Chemical Water Quality" section of this report. The magnitude of the spring flow ranges from seeps and minor measurable amounts to several hundred gallons per minute. Total spring flow in Spring Valley has never been determined but is probably on the order of several thousand acre-feet per year. The spring flow in the model was accounted for in the evapotranspiration amount since these springs support the vegetation and phreatophytes in the valley. As mentioned above the evapotranspiration volume calculated by the model for Spring Valley is about 70,000 acre-feet per year.

Hydraulic Characteristics

The hydraulic characteristics govern how the water introduced by recharge or interbasin flow moves through the modelled area to the areas of discharge. For a steady state simulation the important hydraulic characteristics are transmissivity, boundary conditions (conductances) and, since this is a two layer model, vertical leakance. These parameters are discussed below:

Boundary Conditions

Each individual basin was modelled as a "free body" tied to general head boundaries outside the existing basin boundary. The water levels specified for the general head boundaries were based on Thomas et al. (1986) for each layer. Conductances were established to simulate the USGS estimates for inflow and outflow in each layer, as well as match existing water levels. Figures 17 and 18 show the location of the general head boundaries and the conductances used in each layer.

Inflow

Harrill et al. (1988) estimate that about 2000 acre-feet per year enter Spring Valley from Tippet Valley in the northern part through the consolidated rocks. This water then flows south into Spring Valley toward the playa area. The model lower boundary conditions result in about 1700 acre-feet per year entering Spring Valley from Tippett Valley.

Outflow

Rush and Kazmi (1965) and Harrill et al. (1988) estimate that about 4000 acre-feet per year exit southeastern Spring Valley in the consolidated rocks through the trough area south of the Snake Range into Snake Valley. The model lower boundary conditions result in about 3,700 acre-feet per year exiting southeastern Spring Valley.

Transmissivity

Transmissivity values were assigned based on rock type. The USGS digital representation of the 1:500,000 scale Nevada Geology (Turner and Bawiec, 1992) was used to classify rock types into transmissivity zones. A raster file of the geology was created from the digital map by using the gridding function in ARC Info, subsetting a number corresponding to the geology type every half a mile for the complete CWP regional model area. This grid was then subset on mile nodes for the area corresponding to the Spring Valley model, which included sixteen different geologic classifications as shown in Figure 14.

As part of the MX Missile siting investigation a couple of aquifer tests were conducted in the alluvium in Spring Valley; however, the results of these tests are reported by Bunch and Harrill (1984) as inconclusive. As part of the water resources investigation of Spring Valley by Leeds, Hill, and Jewett, Inc (1983) conducted for Los Angeles Department of Water and Power three well were drilled in Spring Valley. Aquifer tests of these wells yielded the results shown in Table 3. The composite value of transmissivity for both the unconfined and confined aquifers was calculated at about 3300 ft^2 per day with the upper value for unconfined at about 5100 ft^2 per day and the lower value for confined at about 1900 ft^2 per day.

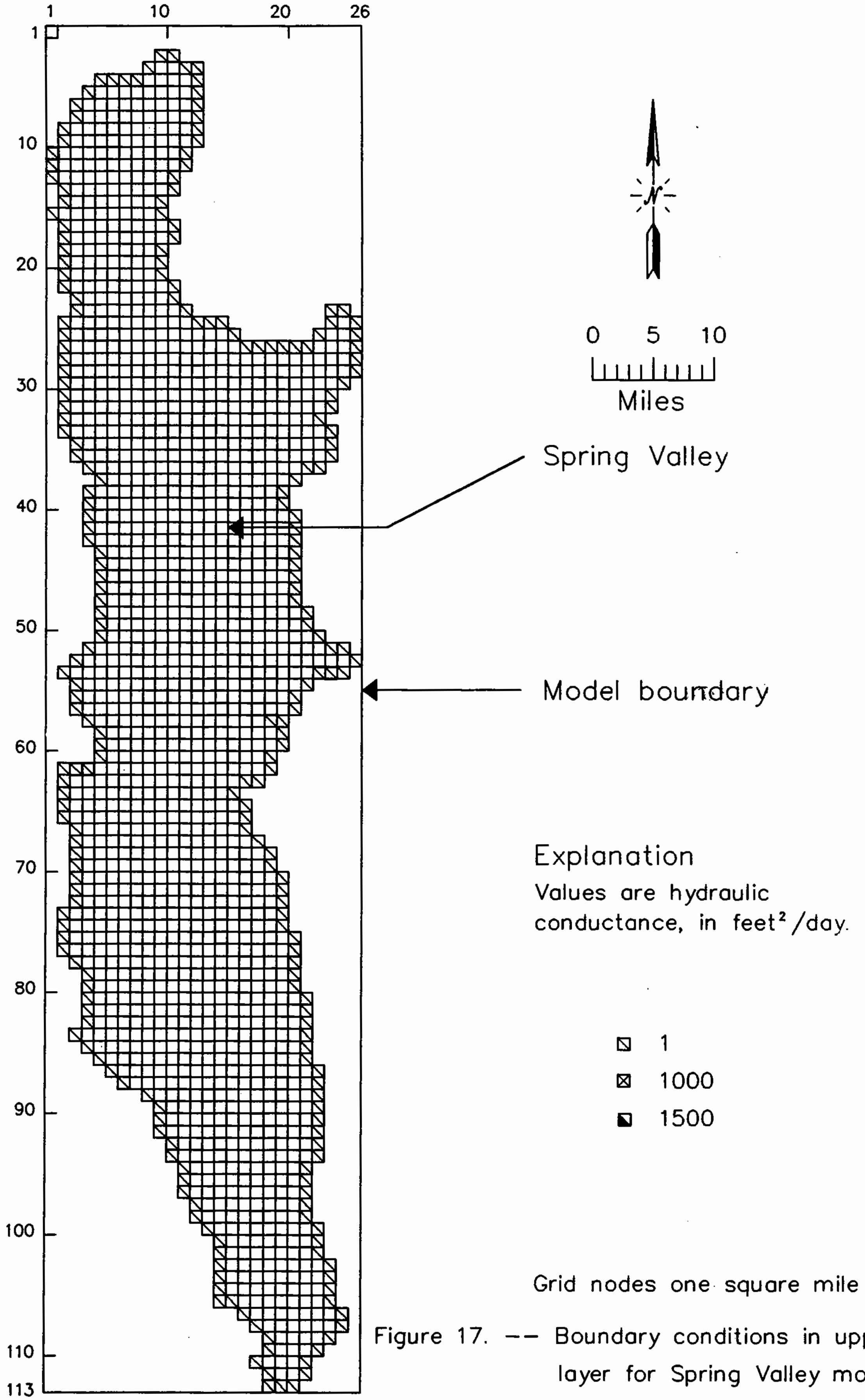


Figure 17. -- Boundary conditions in upper layer for Spring Valley model.

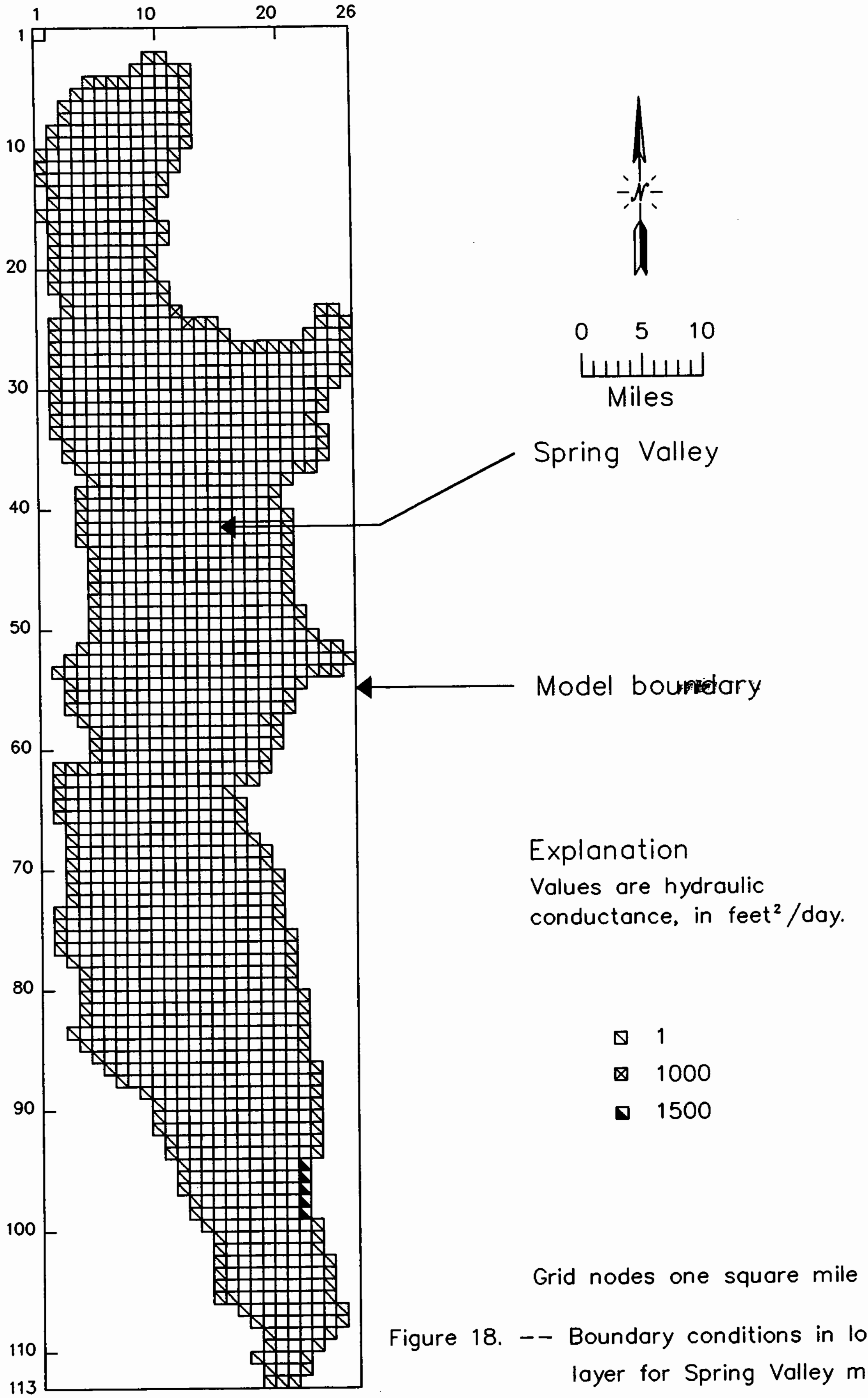


Figure 18. -- Boundary conditions in lower layer for Spring Valley model.

Initially in the upper layer the transmissivity values of 5000 ft^2 per day was assigned to alluvium, about 2000 ft^2 per day for playa deposits, around 1000 ft^2 per day for the carbonate rock types, and about 250 ft^2 per day or slightly lower for clastics and volcanic rock classifications. In calibrating the model, over 100 wells were evaluated and after checking land surface elevations and deleting duplicate data sets, 58 were considered (Table 1) to provide an areal coverage of depth to water, and were used in the model calibration, which are all completed in the alluvium. It became apparent that the transmissivities of the alluvium and playa deposits were too high because the majority of the simulated water levels were much lower than the observed values. The model is only a two layer model allowing transmissivity values for the upper alluvial system and the consolidated rocks. There is insufficient data to warrant modelling the alluvial system with more than one layer. To match water levels it was necessary to use lower transmissivity values for most all the units in the upper layer. Transmissivity values used for the upper layer are shown in Figure 19. It was also necessary to further reduce transmissivities in an area of the Schell Creek Range which is also shown in Figure 20. Simulated water levels in this area in wells near the western spring line were significantly lower than actual levels. Reducing the transmissivity in this area better simulates the spring line and better matches existing water levels in this area.

There are no wells completed in the consolidated rock in Spring Valley, therefore initial estimates of transmissivities for the lower layer were based on other consolidated rock wells as well as other models prepared for valleys within the carbonate rock province. Carbonate rocks were assumed to be underlying the alluvium and playa deposits and a value of 1000 ft^2 per day were initially assigned to those. During calibration the value for the consolidated rock that seemed to provide the best match of the alluvial water levels was 2000 ft^2 per day. However, the same area of lower transmissivity in the Schell Creek Range discussed above was also used in the second layer. The resulting transmissivities for the lower layer are shown in Figure 20.

Vertical Leakance

The vertical leakance value establishes the connection between the upper and lower model layers and were calculated as specified by McDonald and Harbaugh (1988) based on assumptions of an overall general thicknesses of 4000 feet for the alluvium and 15,000 feet for the bedrock. Recalculation was done as transmissivity values varied significantly during calibration. For most all the transmissivity units the vertical conductance remained generally around 1.5 to 2.5 x 10^{-5} ft per day. For simplicity an overall value of 1.9 x 10^{-5} was used.

The sensitivity of the vertical leakance values is discussed in more detail in the section titled "Steady State Simulation".

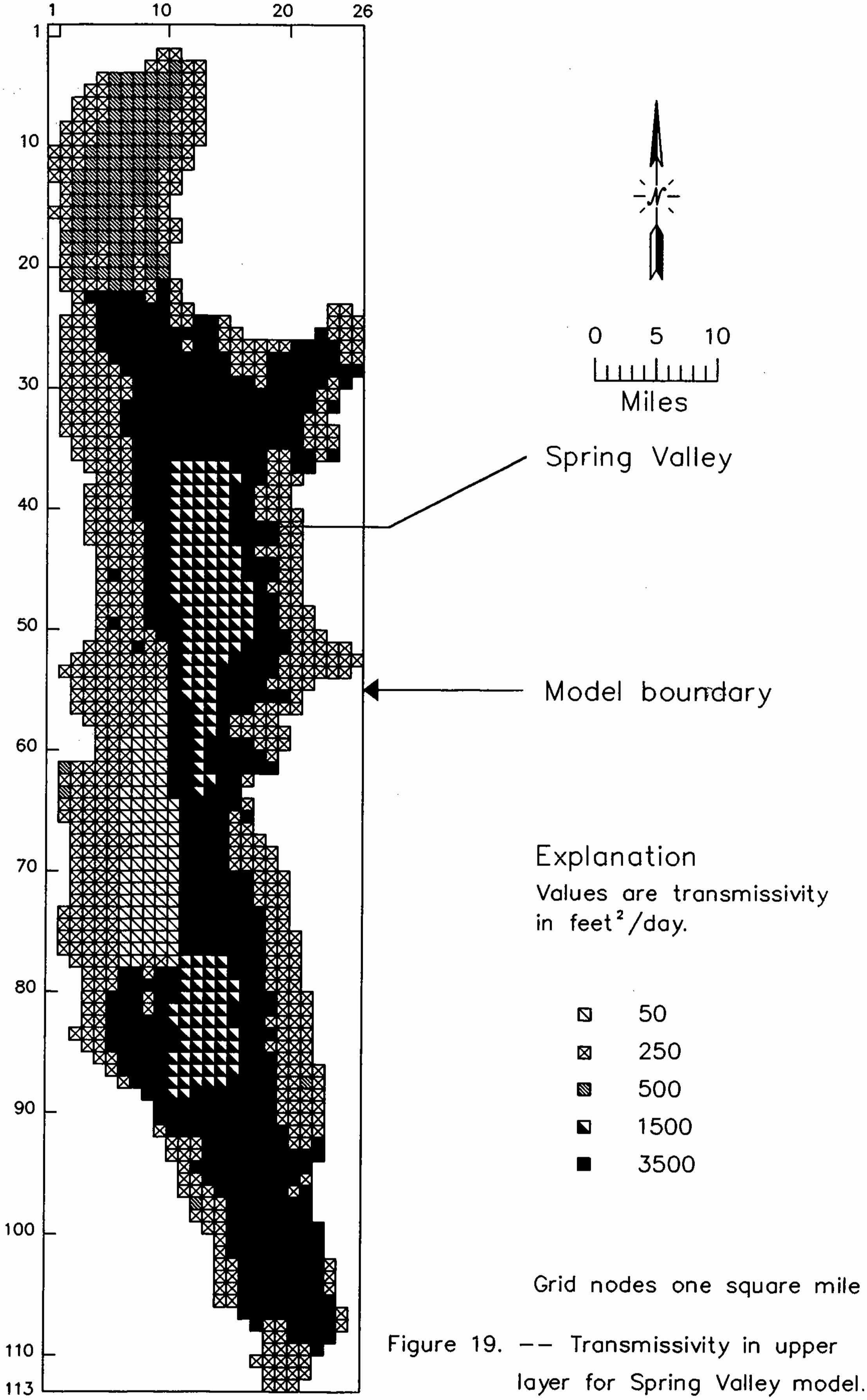


Figure 19. -- Transmissivity in upper layer for Spring Valley model.

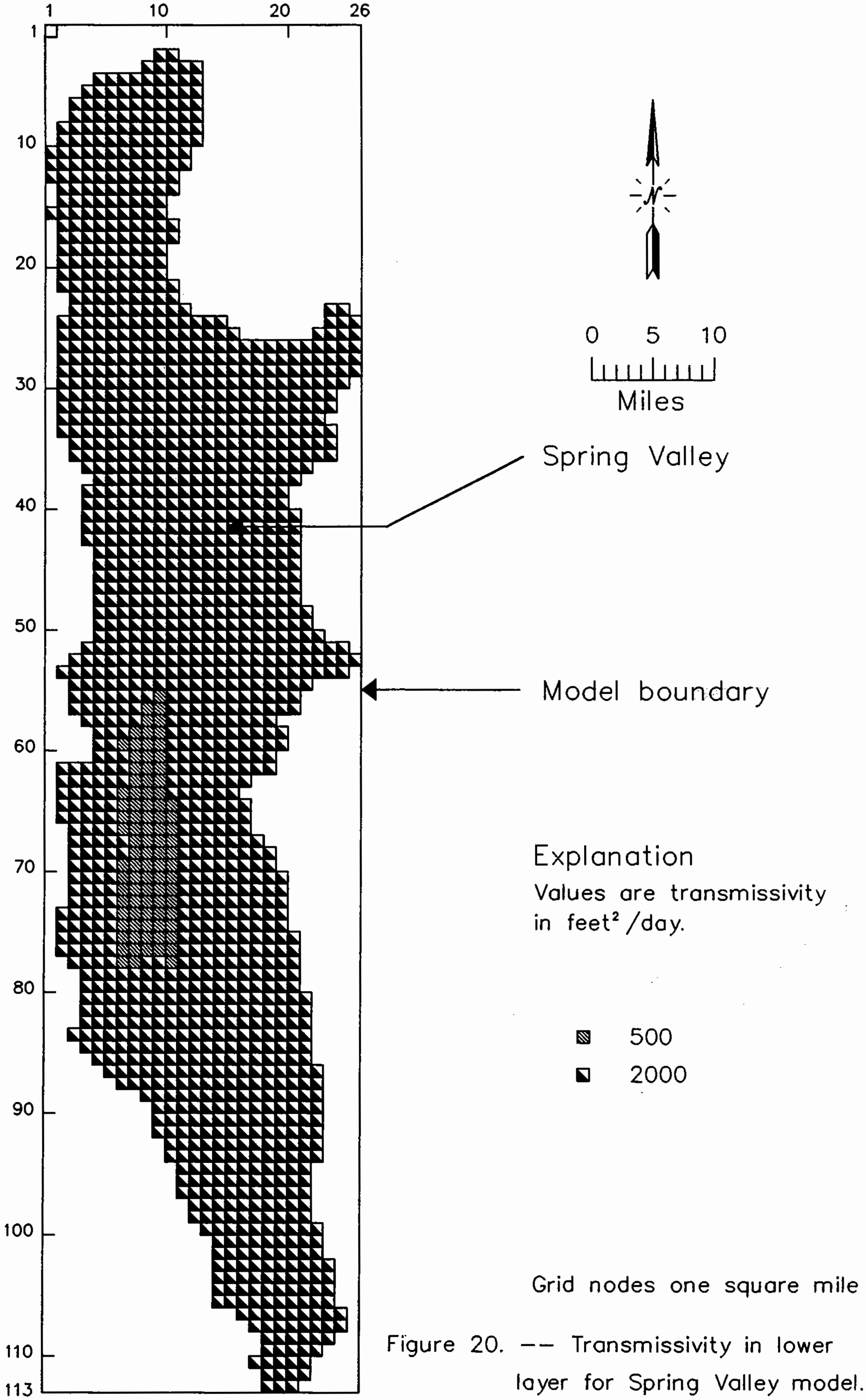


Figure 20. -- Transmissivity in lower layer for Spring Valley model.

Steady State Simulation

The potentiometric surfaces for the upper and lower layers resulting from the steady state simulation for Spring Valley are shown in Figures 21 and 22 with the actual water levels imposed for the upper layer. There are no water level measurements in the bedrock or lower layer.

Upper Layer

Table 11 shows the 58 wells used for calibration and the differences between the actual and simulated water levels for the Spring Valley model. These measurements are the complete water levels included in Table 1, with the same ID numbers.

Figure 23 graphically illustrates the difference between the actual water levels and the model simulated levels for wells located from south to north Spring Valley. Of the 58 calibration points 95% are within 100 feet of the actual measurements, 83% being within 50 feet, 79% being within 40 feet and 57% being within 20 feet of the actual measurements. Also the distribution of positive and negative residuals is about even.

Overall the match of the simulated values with the actual values is thought to be reasonable as well as the match with the USGS budget. Therefore, the steady state model provides a reasonable simulation of the potentiometric surface.

Lower Layer

The potentiometric surface generated by the model for the lower layer is shown in Figure 22. There are no wells completed in the consolidated rock. As discussed in the section titled "Boundary Conditions" the general head boundaries are based on regional water levels found in Thomas et al. (1986). The contours indicating the potentiometric surface found in Thomas et al. (1986) for this area are dashed because there are no hard data to indicate the gradient in the consolidated rock aquifer, so values based on the upper heads were used. Only two transmissivity values were used for the lower layer as discussed above, with one area of low transmissivity to keep simulated water levels high enough to match existing water levels. Outflow from Spring Valley is estimated at 4000 acre-feet per year to Hamlin Valley. The steady state model matches this estimate.

Based on the ground-water data and the uncertainties of the volume and flowpaths, the steady state model provides a reasonable match to existing water levels and the USGS ground-water budget. Table 12 compares the ground-water budget found in Rush and Kazmi (1965) with the model generated budget.

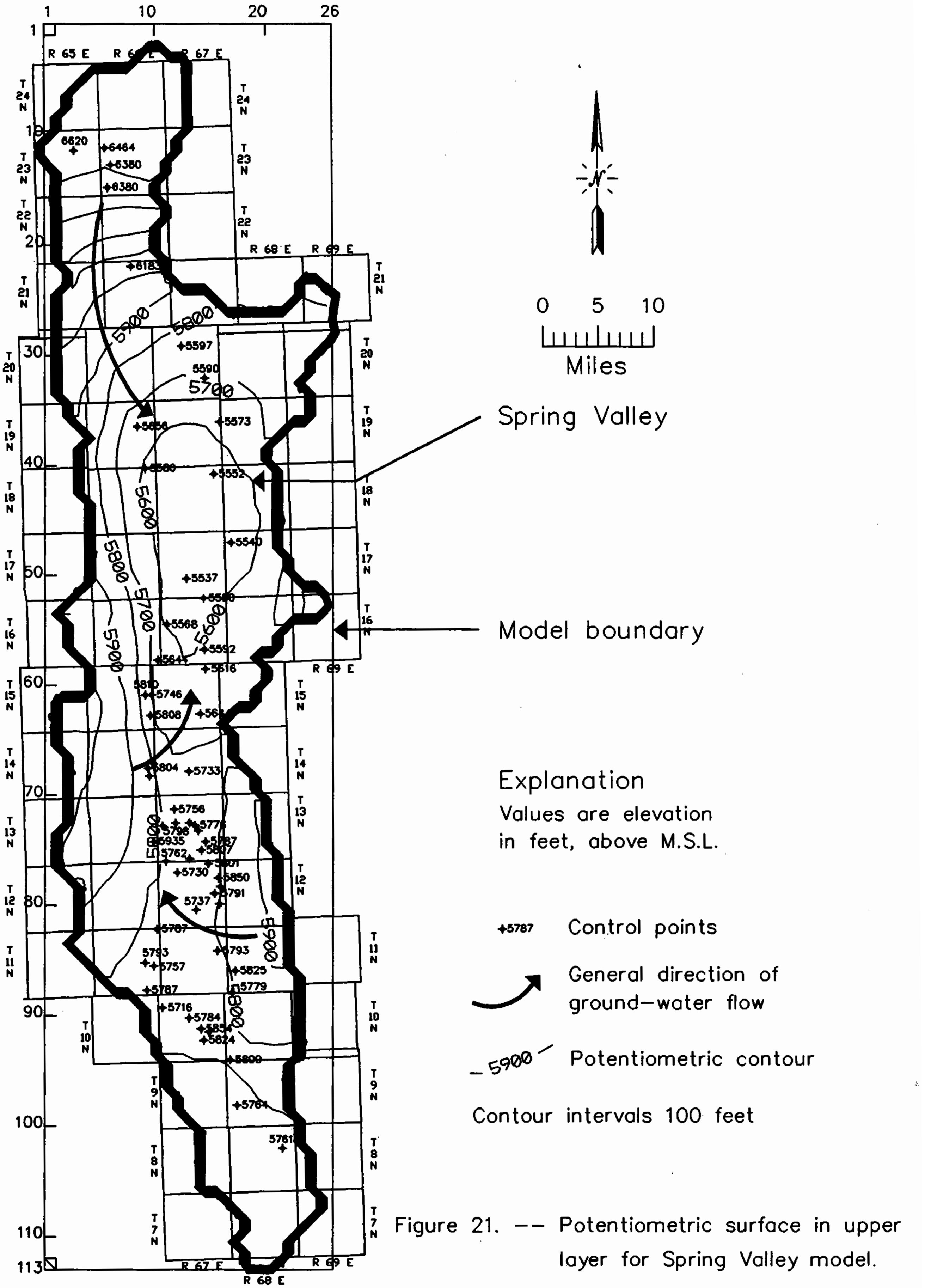


Figure 21. -- Potentiometric surface in upper layer for Spring Valley model.

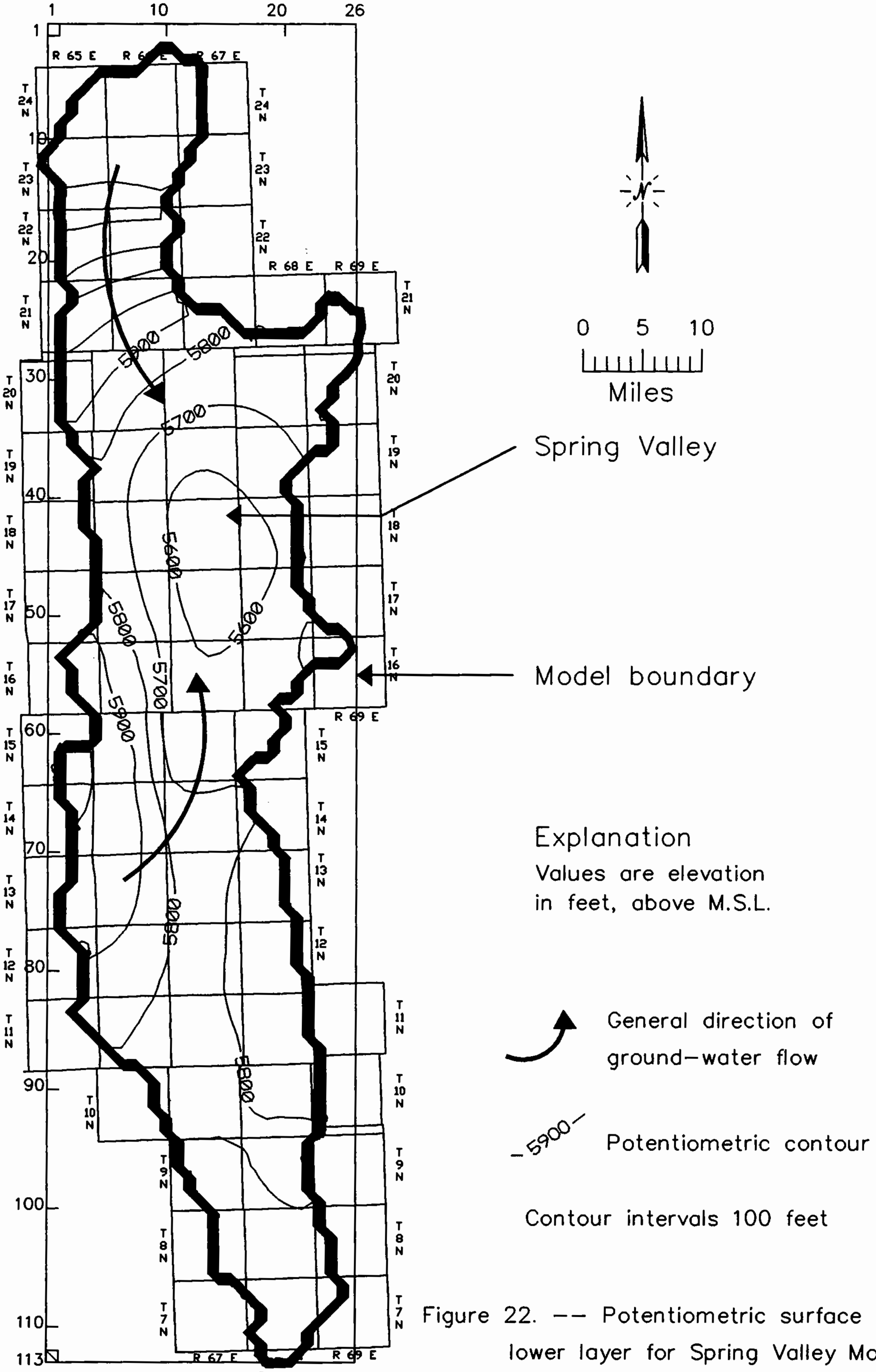


Figure 22. -- Potentiometric surface in lower layer for Spring Valley Model.

Table 11.--Comparison of actual vs. simulated water levels for wells used in calibration.

Well ID No.	Location	Row	Column	Water Level (feet above sea level)		Residual Δ
				Actual	Simulated	
1	8N-68E 23BAC	103	22	5762	5824	-62
2	10N-67E 7BA	90	11	5716	5780	-64
3	11N-66E 24BDA	86	10	5757	5780	-23
4	11N-66E 1AAB	83	11	5788	5777	11
5	11N-66E 23AB	86	10	5793	5780	13
6	11N-66E 35DBA	88	10	5782	5775	7
7	9N-68E 30AAA	99	18	5765	5808	-43
8	10N-68E 31CD	95	17	5800	5800	0
9	11N-68E 19CDC	86	18	5825	5808	17
10	11N-68E 31CDC	88	17	5780	5796	-16
11	10N-67E 16AAB	91	14	5785	5788	-3
12	10N-67E 22AA	92	15	5854	5794	60
13	10N-67E 23ACB	92	15	5772	5794	-22
14	10N-67E 26BB	93	15	5825	5797	28
15	11N-67E 13B	85	16	5793	5790	3
16	17N-67E 28A	51	13	5538	5548	-10
17	20N-67E 9BA	30	13	5598	5751	-154
18	16N-67E 18A	55	11	5569	5607	-38
19	18N-66E 1B	41	10	5580	5579	1
20	17N-68E 7AB	47	17	5540	5552	-12
21	16N-67E 3AAA	53	15	5581	5583	-2
22	16N-67E 27DAD	57	15	5592	5609	-17
23	18N-67E 1CCA	41	16	5552	5569	-17
24	19N-67E 13AAA	37	16	5574	5614	-40
25	20N-67E 26ABB	33	15	5591	5685	-94
26	12N-67E 8A	78	12	5730	5767	-37
27	13N-67E 8ACA	72	12	5756	5769	-13
28	13N-67E 31DDC	77	11	5763	5798	-35
29	15N-66E 13D	61	10	5746	5712	34
30	16N-66E 36DBA	58	11	5644	5620	24

Table 11.--Comparison of actual vs. simulated water levels for wells used in calibration (Continued).

Well ID No.	Location	Row	Column	Water Level (feet above sea level)		Residual Δ
				Actual	Simulated	
31	19N-66E 14AB	37	9	5657	5658	-1
32	13N-67E 17DBA	73	12	5778	5773	5
33	13N-67E 18DCB	73	11	5799	5804	-5
34	14N-66E 24AAB	68	10	5815	5815	-0
35	14N-66E 24BDD	68	10	5804	5815	-11
36	14N-66E 25BAD	69	10	5819	5823	-4
37	15N-66E 25DAD	63	10	5809	5730	79
38	12N-67E 27B	81	14	5737	5782	-45
39	14N-67E 22CCC	68	14	5733	5727	6
40	15N-67E 2DAC	59	15	5618	5621	-3
41	15N-67E 26CA	63	15	5645	5658	-13
42	12N-67E 2ACB	77	15	5801	5780	21
43	12N-67E 12CAA	78	16	5851	5796	55
44	12N-67E 13A	79	16	5892	5795	97
45	12N-67E 24BBB	79	16	5791	5795	-4
46	12N-67E 24CDD	80	16	5824	5796	28
47	13N-67E 15CBB	73	14	5776	5779	-3
48	13N-67E 15CDA1	73	14	5777	5779	-2
49	13N-67E 22ADB	74	14	5788	5779	9
50	13N-67E 26BAD	75	15	5787	5787	0
51	13N-67E 33DDA	76	14	5769	5773	-4
52	13N-67E 34AAA	76	15	5808	5783	25
53	13N-66E 25A	75	10	5936	5833	103
54	21N-66E 4B	22	8	6059	6068	-9
55	23N-66E 19A	13	6	6380	6413	-33
56	23N-66E 31AB	15	6	6380	6368	12
57	23N-65E 10D	12	3	6620	6452	168
58	23N-66E 7C	12	6	6464	6445	19

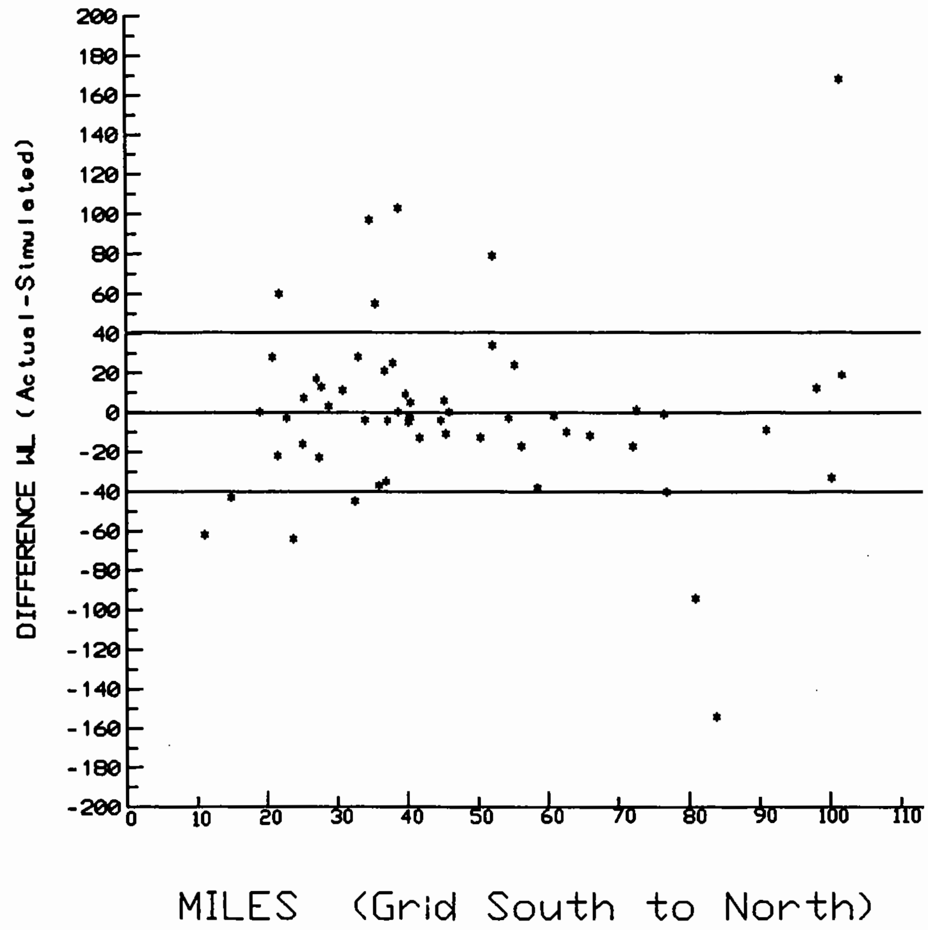


Figure 23.--Difference between actual and simulated water levels.

Table 12.--Comparison of Spring Valley model ground-water budget with USGS (Hood and Rush, 1965, and Harrill et al., 1988) all values ac.ft./yr.

	USGS (Hood and Rush (1965)) (Harrill et al. (1988))	Steady State Model (rounded)
INFLOW:		
RECHARGE	75,000	72,000
From: Tippett Valley	2,000	2,000
Total:	77,000	74,000
OUTFLOW:		
ET	70,000	70,000
To: Hamlin Valley	4,000	4,000
Total:	74,000	74,000

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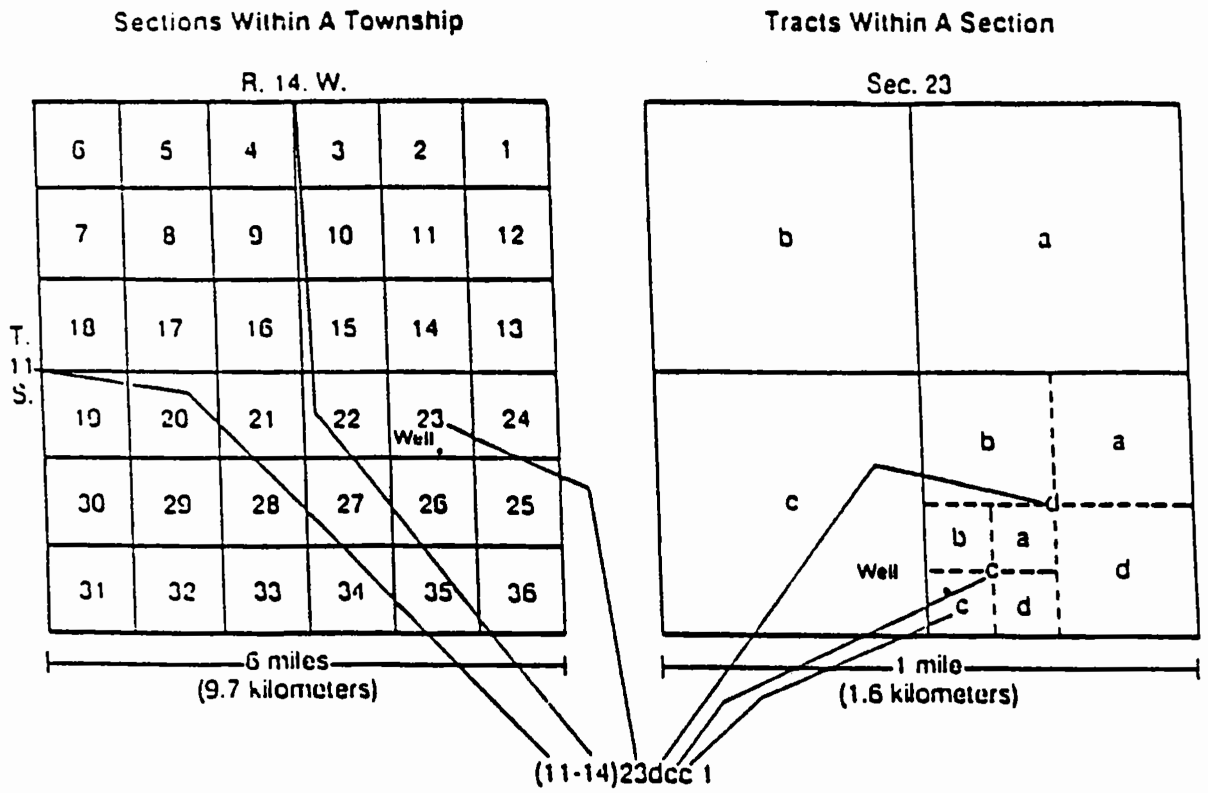
APPENDIX A

LOCATION DESIGNATION



Well and spring locations are designated with respect to the Mount Diablo baseline and meridian as shown diagrammatically above. The first number within the parentheses represents the township south of the baseline and the second number represents the range east of the meridian. The section number follows along with the section 1/4, section 1/16th, and section 1/64th. The letter designations a, b, c, and d refer to the northeast, northwest, southwest, and southeast, respectively. If more than one well occurs within the same 1/64th section, a numerical identifier is added to the end of the designation. Thus (28-63) 27aba1 represents the first well of record in the northeast quarter-section of the northwest quarter-section of the northeast quarter-section of Township 28 South, Range 63 East, Section 27.

APPENDIX B

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion				Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
714	02/12/10	NW	35	13N	67E	0.0000	105.00	140.00	Irrigation & Domestic	SURF_PE	NW S35 T13N R67E	PROOF 0714. No diversion rate given.
767	01/01/92	NW NE	34	18N	68E	0.0000	0.00	0.00				PROOF 0760. No proof in file
788			13	18N	66E	0.0000	0.00	0.00	Irrigation & Domestic	SURF_PE		PERMIT 0788. No proof in file
789	01/01/75	SE NW	2	18N	66E	0.0000	0.00	0.00	Irrigation & Domestic	SURF_PE	NW, W2 NE S1, W2 NE S2 T18N R66E, S2 SE, NW, E2 SW S35, SW, NW S25, E2 SE S26 T19N R66E	PERMIT 0789. No amounts given on proof
790	01/01/73	NW NW	6	16N	66E	2.5000 10	500.00 14	000.00	Irrigation & Domestic	SURF_PE	POR SECS 12, 13 T16N R66E, SECS 5-8, 17-20, 29, 30 T16N R67E	PERMIT 0790. Comingled with 01217, 01218, 02819-02828, 02852
791	01/01/90	NW SE	1	17N	66E	0.0000 5	760.00 7	680.00	Irrigation & Domestic	SURF_PE	T17N R67E	PERMIT 0791. No diversion rate given. Comingled with 01215 & 10710
802 25	01/28/08	SW NE	18	21N	66E	0.0250	0.00	0.00	Stockwater	SURF_OTH	SW NE S18 T21N R66E	No duty given
811 131	02/08/08	NW NE	34	12N	67E	2.8000	840.00 1	120.00	Irrigation	SURF_PE	NW S27, S2 SW S22, NW SW S22 T12N R67E	
813 659	02/08/08	SW SW	8	12N	68E	0.2000	0.00	0.00	Irrigation	SURF_PE	NE SE S13 T12N R67E	2ND POD NE S13 T12N R67E. See also 02860.
920 866	04/16/08	NE NE	22	13N	67E	1.8133	0.00	0.00	Irrigation & Domestic	SURF_PE	NW, W2 NE, N2 SW, W2 SE, SE SW S22 T13N R67E	SEE 22545 & 15812
983 171	05/26/08	SW SE	2	14N	68E	1.0000	0.00	0.00	POWER & Milling	SURF_PE	NE S3 T13N R67E	No duty given
1026	01/01/98	NE NE	12	12N	67E	0.0000	240.00	320.00	Irrigation	SURF_PE	W2 SW S12 T12N R67E	PERMIT 01026. No diversion rate given.
1052 244	07/13/08	NE NW	6	13N	67E	0.2000	45.00	60.00	Irrigation	SURF_PE	NW NW S6 T13N R68E, E2 NE S1 T13N R67E	SEE CERT 1761
1080	01/01/87	NW NE	16	16N	68E	0.0000	199.89	266.52	Irrigation	SURF_PE	N2 S16, N2 S17, NW S16 T16N R68E	PERMIT 01080. No diversion rate given.
1090	01/01/95	NE NE	11	21N	68E	0.3000	0.33	0.33	Stockwater	SURF_OTH	NE NE S11 T21N R68E	PERMIT 01090
1111 23	08/31/08	NW SW	10	20N	66E	0.0250	0.00	0.00	Stockwater	SURF_OTH	NW SW S10 T20N R66E	No amount given
1125	08/06/12	NE NW	25	14N	67E	0.0000	0.00	0.00	Mining, Milling & Domestic	SURF_PP	NE NW S25 T14N R67E	PERMIT 01125. No amounts given. Is this really a PP?
1213	01/01/88	SE NE	4	18N	66E	0.0000	960.00 1	280.00	Irrigation	SURF_PE	W2 S13, S2 SW S12 T18N R66E	PERMIT 01213. No diversion rate given. Comingled with 13457
1214	01/01/87	NW SE	26	18N	66E	0.0000 1	500.00 2	000.00	Irrigation & Domestic	SURF_PE	SE S25, NE NE S36, E2 NE, NW NE S25, E2 SE S24 T18N R66E, W2 W2 S30 T18N R67E	PERMIT 01214. No diversion rate given. Comingled with 28818

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion				Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
1215	01/01/86	NW SE	1	17N	66E	4.0000	0.00	0.00	Irrigation	SURF_PE	E2 E2 S12 T17N R66E, W2, W2 E2 S6, W2, W2 E2 S7 T16N R67E, W2 W2 E2 S31 T18N R67E, NW, SW S31 T18N R67E, N2 S6, N2, SW S7 T17N R67E, NE, SE S12 T17N R66E	PERMIT 01215. SEE 0791
1216	01/01/83	SE NE	23	15N	66E	0.0000	600.00	800.00	Irrigation	SURF_PE	S24 T15N R66E, W2 NE, E2 NW, NE SW, NW SE S24 T15N R66E	PERMIT 01216. No diversion rate given
1217	01/01/73	SE NW	24	16N	66E	0.0000	0.00	0.00	Irrigation	SURF_PE	S7, 18, 3/4 S8, 3/4 S17, S19, 20 T16N R67E	PERMIT 01217. 2ND POD AT SE SW S13 T16N R67E, 3RD POD AT NW NW S7 T16N R67E. No diversion rate given
1218	01/01/73	NE NW	6	16N	67E	0.0000	0.00	0.00	Irrigation	SURF_PE	E2, E2 W2 S6, W2, W2 E2 S5 T16N R67E	PERMIT 01218. No diversion rate given. See 0790
1219	02/01/13	SE NW	2	18N	66E	7.7280 1	410.00 1	880.00	Irrigation	SURF_PE	S1, S2 T18N R66E, S35, S36 T19N R66E	PERMIT 01219
1220		SW NE	31	17N	67E	0.0000	0.00	0.00		SURF PE		PERMIT 01220. No proof in file
1467	01/01/83	SW SW	36	19N	67E	0.0000	480.00	640.00	Irrigation	SURF_PE		PERMIT 01467. No diversion rate given. 2ND POD AT NE SW S36 T19N R67E
1520 107	11/15/09	SW SW	33	21N	66E	0.0800	24.00	32.00	Irrigation & Stockwater	SURF PE	SW SW S33 T21N R66E	
1614	05/15/19	NE NE	12	14N	67E	0.0000	0.00	0.00	PLACER Mining	SURF PE	NONE GIVEN	PERMIT 01614. No amounts given
1616 109	02/18/10	NW NW	26	19N	68E	0.0060	8.06	8.06	Stockwater & Domestic	SURF OTH	NW NE S27 T19N R68E	
1637	09/15/19	NE SW	14	13N	65E	0.1000	8.96	8.96	Stockwater	SURF OTH	NE SW S14 T13N R65E	PERMIT 01637
1648	01/01/91	NW SW	27	18N	68E	1.0000	225.48	300.64	Irrigation	SURF PE	E2 S31 T18N R68E	PERMIT 01648. Comingled with 2923
1665	12/15/19	NE SE	35	12N	65E	0.0250	11.20	11.20	Stockwater	SURF OTH	NE SE S35 T12N R65E	PERMIT 01665
1669	04/19/20	SE SW	2	12N	65E	0.0250	11.20	11.20	Stockwater	SURF OTH	SE SW S2 T12N R65E	PERMIT 01669
1686	01/01/80	NE NW	3	21N	65E	0.0000	202.05	270.00	Irrigation	SURF_PE	NE NE, NW NE S1 T21N R65E, NE NW, NW NW S6 T21N R66E	PERMIT 01686. No diversion rate given
1724 184	06/15/10	NE SW	15	17N	68E	0.0100	0.00	0.00	Stockwater & Domestic	SURF OTH	WITHIN T17N R68E	No amount given
1728	09/13/20	NW NE	5	7N	68E	0.0300	13.44	13.44	Stockwater	SURF_OTH	SW SE S32 T7N R68E, NW NE S5 T6N R68E	PERMIT 01728
1764	01/01/04	NE SW	30	17N	67E	0.0000	30.00	40.00	Irrigation	SURF PE	NE SW, NW SE S30 T17N R67E	PERMIT 01764. No diversion rate given
1900 117	12/07/10	SW SW	2	17N	68E	0.0250	4.60	4.60	Stockwater & Domestic	SURF OTH	SW SW S2 T17N R68E	
1901 118	12/07/10	SW NE	22	18N	68E	0.0250	4.59	4.59	Stockwater & Domestic	SURF OTH	SW NE S22 T18N R68E	
1922 179	02/02/11	SE NE	19	15N	68E	0.2000	0.00	0.00	Stockwater & Domestic	SURF OTH	E2 SE S19 T15N R68E	NO STOCK COUNT

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion				Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
1969	01/01/72	NW SW	15	20N	66E	1.0000	300.00	400.00	Irrigation	SURF PE	S22, 23,15,27, T20N R66E	PERMIT 01969
2005 406	04/12/11	N2 NE	35	13N	67E	0.8000	0.00	0.00	Irrigation & Domestic	SURF PE	NE NE , NW NE S35 T13N R67E	SEE 28790
2108 29	06/16/11	SE SE	30	14N	68E	0.0250	0.00	0.00	Stockwater	SURF OTH	SE SE S30 T14N R68E	No amount given
2245 8112	06/16/65	NE SW	12	12N	67E	0.6100	45.00	60.00	Irrigation & Domestic	WELL PE	NE SW S12 T12N R67E	
2261 215	11/21/11	SE SE	13	16N	65E	0.0100	0.00	0.00	Irrigation, Stockwater & Domestic	SURF_OTH	SE SE S13 T16N R65E	No amounts given
2286	01/01/75	SW NW	16	20N	66E	2.0000	87.61	116.81	Irrigation	SURF PE	SW NE, NW NE S16 T20N R68E	PERMIT 02286
2305	09/13/40	NW NE	34	20N	66E	0.0000	0.00	0.00	Irrigation	SURF PE		No proof in file
2332	02/06/46	SW SE	28	20N	66E	0.0000	0.00	0.00	Irrigation	SURF PE		PERMIT 02332. No proof in file
2486 258	08/09/12	NW SW	29	14N	68E	0.2000	0.00	0.00	Mining, Milling & Domestic	SURF_PE	NE NW S25 T14N R67E	No duty given
2710 259	05/12/13	SE SE	30	14N	68E	0.2000	0.00	0.00	Mining, Milling & Domestic	SURF_PE	NE NW S25 T14N R67E	No duty given
2745 167	06/30/13	SW NE	31	17N	67E	0.2000	0.00	0.00	Stockwater & Domestic	SURF OTH	SW NE S31 T17N R67E	No duty given
2804	01/01/71	SW SW	24	18N	66E	1.1200	949.41 1	265.88	Irrigation	SURF_PE	S2 NW, S2 NE, SW1/4, W2 SE S24, N2 NW S25 T18N R66E	PERMIT 02804
2807	01/01/09	NE NW	29	18N	66E	0.0150	3.54	3.54	Stockwater	SURF OTH	NE NW S29 T18N R66E	PERMIT 02807
2808	01/01/09	SE NE	1	18N	65E	0.0150	3.71	3.71	Stockwater	SURF OTH	SE NE S1 T18N R65E	PERMIT 02808
2819	01/01/85	NE SE	18	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	W2 E2, W2 S5, E2 S6, E2, E2 W2 S7, W2, W2 E2 S8, W2 NE, NW SE, W2 S17, NE, NE SE S18 T16N R67E	PERMIT 02819. SEE 0790
2820	01/01/85	SE SE	18	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02820. SEE 0790
2821	01/01/85	NE NE	19	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02821. SEE 0790
2822	01/01/85	SW SW	17	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02822. SEE 0790
2823	01/01/85	NW NW	20	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02823. SEE 0790

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Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
2824	01/01/85	NE SE	19	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02824. SEE 0790
2825	01/01/85	SE NE	19	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02825. SEE 0790
2826	01/01/85	SW NW	20	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02826. SEE 0790
2827	01/01/85	NW SW	20	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02827. SEE 0790
2828	01/01/85	SE NW	20	16N	67E 1	0.0000	0.00	0.00	Irrigation	SURF_PE	SEE 02819	PERMIT 02828. SEE 0790
2834	01/14/74	NE NW	16	13N	68E	0.0150	4.56	4.56	Stockwater	SURF_OTH	NATURAL CHANNEL BETWEEN POINTS IN NE NW S16 T13N R68E, NE SE S18 T13N R68E	PERMIT 02834. 2ND POD AT NE SE S18 T13N R68E
2835	01/14/74	NE NE	32	13N	68E	0.0150	4.56	4.56	Stockwater	SURF_OTH	NE NE, NW NW S32 T13N R68E	PERMIT 02835. 2ND POD AT NW NW S32 T13N R68E
2836	01/14/74	SW SE	3	11N	68E	0.0150	4.56	4.56	Stockwater	SURF_OTH	SW SE S3 T11N R68E	PERMIT 02836
2837	01/14/74	SW SE	20	13N	68E	0.0150	4.56	4.56	Stockwater	SURF_OTH	SW SE, NW SW S20 T13N R68E	PERMIT 02837. 2ND POD AT NW SW S20 T13N R68E
2838	01/14/74	NE SW	16	13N	68E	0.0150	4.56	4.56	Stockwater	SURF_OTH	NE SW S16, NE SW S17 T13N R68E	PERMIT 02838. 2ND POD AT NE SW S17 T13N R68E
2842	03/25/74	SW NW	28	13N	68E	0.5000	4.27	4.27	Stockwater	SURF_OTH	SW NW S28 T13N R68E	PERMIT 02842
2851	04/17/75	SW NE	26	13N	67E	0.0000	0.00	0.00	Irrigation & Stockwater	SURF_PE	NW NE, NW1/4 S35 T13N R67E	PERMIT 02851. Diversion rate varies, based on amount of precipitation yearly. SEE 28790
2852	04/17/75	NW SW	25	13N	67E	0.0000	0.00	0.00	Irrigation & Stockwater	SURF_PE	NW NE, NW1/4 S35 T13N R67E	PERMIT 02852. SEE 28790. 2ND POD AT SW SW S25 T13N R67E
2852 902	12/01/13	NW NW	25	16N	66E	8.0216 1	804.86 2	406.48	Irrigation	SURF_PE	S2 SW S17, SE SE S18, NE, NE NW, N2 SE, SE SE, S19, W2 NE, W2 SE, W2 S20, W2 NE, NW S29, NE NE S30 T16N R66E	
2853	04/17/75	SW SW	25	13N	67E	0.0000	0.00	0.00	Irrigation &	SURF_PE	NW1/4, N2 NE S35 T13N R67E	PERMIT 02853. 2ND POD AT SW SE S30 T13N R68E. SEE 28790
2854	04/17/75	NW NW	36	13N	67E	0.0000	0.00	0.00	Irrigation & Stockwater	SURF_PE	NW1/4, NE NE S35 T13N R67E	PERMIT 02854. 2ND POD AT SW SE S30 T13N R68E, 3RD POD AT NE NW S31 T13N R68E. SEE 28790

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Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
2855	04/17/75	NW NW	36	13N	67E	0.0000	0.00	0.00	Irrigation, Stockwater & Domestic	SURF_PE	NW1/4, N2 NE S35 T13N R67E	PERMIT 02855. 2ND POD AT NE NE S35 T13N R67E. SEE 28790
2860	07/22/75	NW NW	7	12N	68E	0.00002	270.793	027.72	Irrigation, Stockwater & Domestic	SURF_PE	S11,12,13,14 T12N R67E	PROOF 02860. 2ND POD AT SE S12 T12N R67E, 3RD POD NE SE S31 T13N R68E. No diversion rate given
2861	07/22/75	NE NW	18	12N	68E	0.0000	0.00	0.00	Irrigation, Stockwater & Domestic	SURF_PE	S11,12,13,14 T12N R67E	PROOF 02861. SEE PROOF 02860
3186 567	11/27/14	NE SW	35	17N	67E	1.6000	480.00	640.00	Irrigation	SURF PE	W2 SW, S2 NW S35 T17N R67E	
3203 2624	12/09/14	SE SE	9	16N	67E	0.3500	142.95	190.60	Irrigation & Domestic	SURF PE	SW NE, NW SE S9 T16N R67E	
3383 1036	05/05/15	NE SW	15	17N	66E	0.1996	44.91	59.88	Irrigation	SURF PE	NE SW, NW SE S14 T17N R66E	
3433 1210	06/14/15	NW NW	4	21N	66E	0.7260	196.02	261.36	Irrigation	SURF PE	E2 NW, W2 SE S4 T21N R66E	
3543	01/01/06	SE NW	36	17N	65E	0.0150	4.03	4.03	Stockwater	SURF OTH	SE NW S36 T17N R65E	PERMIT 03543.
3549	01/01/06	NW SW	2	16N	66E	0.0150	4.03	4.03	Stockwater	SURF OTH	NW SW S2 T16N R66E	PERMIT 03549.
3550	01/01/06	SE NE	12	16N	65E	0.0150	4.03	4.03	Stockwater	SURF OTH	SE SE S12 T16N R65E	PERMIT 03550.
3551	01/01/06	NE NW	8	16N	66E	0.0150	4.03	4.03	Stockwater	SURF OTH	NE NW S8 T16N R66E	PERMIT 03551.
3554	01/01/06	NE NW	10	16N	65E	0.0150	4.03	4.03	Stockwater	SURF OTH	NE NW S10 T16N R65E	PERMIT 03554.
3555	01/01/06	NE SE	12	16N	65E	0.0150	4.03	4.03	Stockwater	SURF OTH	NE SE S12 T16N R65E	PERMIT 03555.
3556	01/01/06	SE NW	1	16N	65E	0.0150	4.03	4.03	Stockwater	SURF OTH	SE NW S1 T16N R65E	PERMIT 03556.
3557	01/01/06	SE SW	36	17N	65E	0.0150	4.03	4.03	Stockwater	SURF OTH	SE SW S36 T17N R65E	PERMIT 03557.
3558	01/01/06	SW SW	36	17N	65E	0.0150	4.03	4.03	Stockwater	SURF OTH	SW SW S36 T17N R65E	PERMIT 03558.
3559	01/01/06	SE NW	36	17N	65E	0.0150	4.03	4.03	Stockwater	SURF OTH	SE NW S36 T17N R65E	PERMIT 03559.
3560	01/01/06	NW NE	10	17N	66E	0.0150	3.13	3.13	Stockwater	SURF OTH	NW NE S10 T17N R66E	PERMIT 03560.
3562	01/01/06	NE SE	23	17N	66E	0.0150	3.73	3.73	Stockwater	SURF OTH	NE SE S23 T17N R66E	PERMIT 03562.
3563	01/01/06	SE NE	22	17N	66E	0.0150	3.73	3.73	Stockwater	SURF PE	SE NE S22 T17N R66E	PERMIT 03563.
3793 2377	12/11/15	SE SW	15	16N	68E	0.1022	37.50	50.00	Irrigation	SURF PE	S2 SW S15, N2 NW S22 T16N R68E	
3865 1068	04/06/16	SE SW	6	11N	68E	2.1398	422.07	562.76	Irrigation	SURF_PE	W2 SE S1, NW NE S12, SW NE, E2 NE, E2 SE, SW SE S12, N2 NE S13 T11N R67E	PORTION Comingled with 27743
3926 1475	04/24/16	NW NE	21	16N	68E	0.0250	0.00	0.00	Stockwater	SURF OTH	NW NE S21 T16N R68E	No amount given
3927 469	04/24/16	SW NW	27	17N	68E	0.1000	30.00	40.00	Irrigation & Stockwater	SURF PE	W2 NW S27, SE NE S28 T17N R68E	

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3973 5993	05/13/16	SW NW	10	16N	67E	0.0078	6.72	6.72	Stockwater	SURF OTH	SW NW S10 T16N R67E	
4041 1930	06/29/16	NW NE	14	19N	66E	1.2000	0.00	0.00	Irrigation & Domestic	SURF PE	S2 SE S11, NW NE S14 T19N R66E	SEE 10766
4042 1929	06/29/16	SE NW	11	19N	66E	1.2000	0.00	0.00	Irrigation & Domestic	SURF PE	W2 SW S12, NE SE S11 T19N R66E	SEE 10766
4043 1928	06/19/16	NE SE	27	20N	66E	2.4000	652.50	870.00	Irrigation & Domestic	SURF PE	W2 NW S12, NE1/4 S11 T18N R66E	SEE 10766
4171 1981	10/02/16	NW SE	4	14N	67E	0.0200	14.33	14.33	Stockwater	SURF OTH	SW NE S4 T14N R67E	
4291 1761	02/02/17	NE SW	6	13N	67E	0.3182	95.46	127.28	Irrigation & Domestic	SURF_PE	E2 NE S1 T13N R67E, NW NW S6 T13N R68E	This cert. duplicates lands to the extent of 20 ac. as defined by Cert. 244. Use under both cert's. N.T.E. 0.3182 cfs. Domestic use limited to 0.025 cfs.
4418 660	02/08/08	NE SE	32	13N	68E	4.4970	0.00	0.00	Irrigation	SURF_PE	NW NW, E2 NW, W2 NE, NE NE, NW SW, E2 SW, W2 SE, NE SE S13 T12N R67E	SEE 02860
4722	01/01/85	SW NE	32	14N	68E	0.5000	0.00	0.00	Mining, Milling & Domestic	SURF_PE	NONE GIVEN	PERMIT 04722. No duty given
4951 1209	03/07/18	SE SE	29	21N	66E	0.0836	1.88	2.51	Irrigation	SURF PE	SW SW S28 T21N R66E	
5028 1541	04/26/18	SE NW	27	17N	68E	0.0660	18.00	24.00	Irrigation	SURF PE	SW NW S27, SE NE S28 T17N R68E	
5072 1041	04/26/20	NW SE	14	20N	67E	0.0180	13.44	13.44	Stockwater	SURF OTH	NW SE S14 T20N R67E	
5114 548	06/19/18	SW SW	10	14N	65E	0.0030	1.68	1.68	Stockwater	SURF OTH	SW SW S10 T14N R65E	
5143 517	07/10/18	NE NE	27	9N	67E	0.0150	11.20	11.20	Stockwater	SURF OTH	NE NE S27 T9N R67E	
5247	09/16/18	NW SW	15	20N	66E	2.0000	0.00	0.00	Irrigation	SURF PE	NE S22 T20N R66E	PERMIT 05247. No duty given
5499 562	05/15/19	NE SE	12	14N	67E	5.0000	0.00	0.00	PLACER Mining	SURF PE	N2 SE S12 T14N R67E	No amount given
5691 1325	08/25/19	SE SE	33	17N	67E	1.8950	689.25	919.00	Irrigation	SURF_PE	SE SE S28, NE NE S33, W2 NW, NW SW S34 T17N R67E	
5713 797	09/05/19	NW NW	32	16N	68E	0.0060	5.04	5.04	Stockwater	SURF OTH	NW NW S32 T16N R68E	
5923 1280	12/26/19	NW SW	27	18N	68E	0.8500	0.00	0.00	Irrigation	SURF PE	NE1/4, N2 SE S31 T18N R68E	SEE 01648
6071 1039	04/26/20	NW SW	10	20N	67E	0.0180	13.44	13.44	Stockwater	SURF OTH	NW SW S10 T20N R67E	
6072 1041	04/26/20	NW SE	14	20N	67E	0.0180	13.44	13.44	Stockwater	SURF OTH	NW SE S14 T20N R67E	
6073 1040	04/26/20	SE NE	11	20N	67E	0.0180	13.44	13.44	Stockwater	SURF OTH	SE NE S11 T20N R67E	
6074 1038	04/26/20	NW SW	2	17N	68E	0.1800	13.44	13.44	Stockwater	SURF PE	NW SW S2 T17N R68E	
6075 1037	04/26/20	SW NE	22	18N	68E	0.0180	13.44	13.44	Stockwater	SURF OTH	SW NE S22 T18N R68E	

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6503 1296	06/30/21	NW NW	13	13N	65E	0.0030	2.24	2.24	Stockwater	SURF OTH	NW NW S13 T13N R65E	
6632 1378	02/17/22	NW NW	7	19N	69E	0.0240	11.40	11.40	Stockwater & Domestic	SURF OTH	NW NW S7 T19N R69E	
6644 1939	03/06/22	SE NE	2	18N	68E	0.0090	6.72	6.72	Stockwater	SURF OTH	SE NE S2 T18N R68E	
6754 1623	08/30/22	NW SE	30	17N	67E	0.5380	146.25	195.00	Irrigation & Domestic	SURF PE	SE NE, NE SE S30 T17N R67E	
6834 1211	12/09/22	SE SW	13	13N	67E	0.9730	0.00	0.00	Irrigation	SURF PE	NW1/4 S35 T13N R67E	SEE 28790
6935 1551	07/10/23	NE SW	17	20N	69E	0.0094	6.72	6.72	Stockwater	SURF OTH	NE SW S17 T20N R69E	
7097 1314	04/24/24	NE SE	23	21N	65E	0.0075	5.37	5.37	Stockwater	SURF OTH	NE SW S21 T21N R65E	
7161 1950	06/27/24	SE SE	20	7N	68E	0.0040	0.00	0.00	Stockwater	SURF OTH	E2 SE S20 T7N R68E	No duty given
7446 1515	07/25/25	NE NW	25	14N	66E	0.0190	1.34	1.34	Stockwater	WELL OTH	NE NW S25 T14N R66E	
7497 1618	09/08/25	NE NW	24	11N	66E	0.0075	5.37	5.37	Stockwater	WELL OTH	NE NW S24 T11N R66E	
7700 1481	04/07/26	NE NE	25	12N	65E	0.0156	11.20	11.20	Stockwater	SURF OTH	NE NE S25 T12N R65E	
7724 2170	04/23/26	SE NW	7	14N	68E	0.2000	0.00	0.00	Milling & DOMESTIC	SURF PE	NE SE S12 T14N R67E	No duty given
7725 2171	04/23/26	NE SW	7	14N	68E	0.0820	0.00	0.00	Milling & DOMESTIC	SURF PE	NE SE S12 T14N R67E	No duty given
7847 2221	08/12/26	NW SW	29	19N	66E	2.4840	0.00	0.00	Hydro Electric Power	SURF PE	NE S28 T19N R66E	NON CONSUMPTIVE USE
8074 1365	04/01/27	NW SE	35	11N	66E	0.0500	35.84	35.84	Stockwater	WELL OTH	NW SE S35 T11N R66E	
8075 1366	04/01/27	SE SE	12	14N	66E	0.0500	35.84	35.84	Stockwater	WELL OTH	SE SE S12 T14N R66E	
8076 1367	04/01/27	NE NE	1	11N	66E	0.0500	35.84	35.84	Stockwater	WELL OTH	NE NE S1 T11N R66E	
8077 1368	04/01/27	SW SE	31	13N	67E	0.0500	35.84	35.84	Stockwater	SURF OTH	SW SE S31 T13N R67E	
8104 2065	04/19/27	NW SE	15	20N	66E	0.0125	8.96	8.96	Stockwater	SURF OTH	SE SE S3, SW SW S2 T20N R66E	
8231	07/16/27	NW SW	12	21N	65E	0.0250	8.96	8.96	Stockwater	SURF OTH	SW SW S12 T21N R65E	PERMIT 08231
8393 3213	11/18/27	SE NE	2	16N	67E	1.5120	408.64	544.85	Irrigation	SURF_PE	SW SW S35 T17N R67EW2 NW S2 T16N R67E, E2 NE S3 T16N R67E	
8396 2220	03/28/25	NW SW	29	19N	66E	0.0000	0.00	0.00	Mining, Milling & Domestic	SURF_PE	NE S28 T19N R66E	No amounts given
8525 2409	04/26/28	SW SE	3	8N	67E	0.0125	8.96	8.96	Stockwater	SURF OTH	SW SE S3 T8N R67E	
8542 1720	05/22/28	NE NE	13	19N	67E	0.0250	17.92	17.92	Stockwater	WELL OTH	NE NE S13 T19N R67E	
8701 2626	09/20/28	SW SW	1	18N	67E	0.0125	8.96	8.96	Stockwater	WELL OTH	SW SW S1 T18N R67E	
8713 2410	10/06/28	NE NE	16	10N	67E	0.0130	9.43	9.43	Stockwater	WELL OTH	NE NE S16 T10N R67E	

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8721 2509	10/23/28	SE SW	25	17N	67E	0.0200	14.56	14.56	Stockwater	SURF_OTH	SE SW S25 T17N R67E	
8804 1967	01/02/29	NE NW	6	13N	68E	0.0320	22.40	22.40	Stockwater	SURF_OTH	NE SW S22, NE SE S9 T14N R67E	
9435 2473	04/06/31	NW NE	26	20N	67E	0.0187	13.44	13.44	Stockwater	WELL_OTH	NW NE S26 T20N R67E	
10487 5042	04/08/40	NE NE	2	16N	67E	2.8730	861.90 1	149.20	Irrigation	SURF_PE	E2 SE S34, SW SW S35 T17N R67E, W2 NW S2, NE S3 T16N R67E	
10510 2607	12/16/29	NW NW	25	7N	68E	0.0190	13.44	13.44	Stockwater	SURF_OTH	NW NW S25 T7N R68E	
10703 8088	07/28/41	SE NE	23	15N	66E	4.0000	192.57	256.76	Irrigation	SURF_PE	NW NE W2 SW S19 T15N R67E, E2 SE, NW SE, SW NE S24 T15N R66E	
10710 4011	07/31/41	NE NW	2	17N	66E	3.1000	0.00	0.00	Irrigation	SURF_PE	SW, SE, NE, NW S7, SW, SE, NE NW S6 T17N R67E	SEE 0791
10766 3182	12/29/41	SE SE	22	19N	66E	3.0000 1	210.17 1	614.27	Irrigation	SURF_PE	W2 NE, SE NE, S2 SE S11, SW NW, W2 SW S12, N2 NE S14 T19N R66E	Comingled with 4041, 4042, 4043
10801 5202	04/01/42	SE NW	28	17N	67E	6.0000	207.87	277.16	Irrigation	SURF_PE	NE NW, NW NE S28, SW SE, NW SE S21 T17N R67E	
10843 4870	06/22/42	NE SW	31	19N	67E	0.3110	93.42	124.56	Irrigation	SURF_PE	SW S31 T19N R67E	
10892	11/02/42	SE SE	35	17N	67E	5.0000	600.00	800.00	Irrigation & Domestic	SURF_PP	E2 SE, SE NE S26, N2 NE S35, SW NE S35 T17N R67E	
10913	01/09/43	SE SW	28	20N	66E	3.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SE S22, W2 SW S23 T20N R66E	SEE 10914
10914	01/09/43	SW SE	15	20N	66E	1.0000	720.00	960.00	Irrigation & Domestic	SURF_PP	SE S22, W2 SW S23 T20N R66E	Comingled with 10913
10921 3375	02/03/43	SE SE	23	17N	67E	0.7900	428.19	570.92	Irrigation	SURF_PE	NW SW S24, NE SE S23 T17N R67E	Comingled with 10993
10993 3376	09/01/43	NW SE	24	17N	67E	0.6000	0.00	0.00	Irrigation	SURF_PE	E2 NE S23, NW S24 T17N R67E	SEE 10921
11029	11/29/43	NW NE	10	18N	66E	6.0000	0.00	0.00	Irrigation	SURF_PP	SE S25, NE S36 T19N R66E, W2 NW S31 T19N R67E	SEE 19076
11354 3127	08/11/45	NE NE	10	20N	67E	0.0400	26.43	26.43	Stockwater	WELL_OTH	NE NE S10 T20N R67E	
12467 3702	05/27/48	NE SE	12	11N	67E	0.1000	72.37	72.37	Mining, Milling, & Domestic	WELL_PE	NE SE S12 T11N R67E	
12528	07/07/48	NW NE	34	20N	66E 1	2.0000 1	800.00 2	400.00	Irrigation & Domestic	SURF_PP	S11 THRU 14 T19N R66E	
12571 4946	08/09/48	SW NE	21	15N	68E	0.3340	48.75	65.00	Irrigation & Domestic	SURF_PE	SE NW, SW NE S21 T15N R68E	
13457 4236	07/31/50	SE SE	15	18N	66E	0.3600	0.00	0.00	Irrigation	SURF_PE	NW, N2 SW S13 T18N R66E	SEE 01213
13652 4159	03/05/51	NW NW	21	15N	68E	0.0300	6.00	8.00	Irrigation & Domestic	SURF_PE	NW NW S21 T15N R68E	

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion		Township Range		Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.				AcFt/Yr	Duty AcFt/Yr				
15812 4808	09/27/54	NW NE	13	13N	67E	1.5930	480.00	640.00	Irrigation	SURF PE	SW S22 T13N R67E	Comingled with 920
16890 4672	03/29/46	SW NE	5	13N	66E	0.1000	36.19	72.38	Quasi-Municipal & Domestic	WELL_PE	W2 NE S5 T13N R66E	
17017 4673	02/02/17	NE NW	6	13N	68E	0.3182	72.75	97.00	Irrigation	SURF_PE	N2 NW, SW NW S6 T13N R68E, NE NE, SW NE S1 T13N R67E	
17163 4810	01/28/57	NW NE	22	13N	67E	1.6000	0.00	0.00	Irrigation & Domestic	SURF PE	S2 NW S22 T13N R67E	SEE 22545
17207	03/11/57	SW SE	23	20N	66E 4	2.0000	960.00 1	280.00	Irrigation	SURF_PP	SE SE S13, E2 NE, NE SE S24 T20N R66E, W2 NW, N2 SW S19 T20N R67E	
17605	07/10/58	SW SE	28	20N	66E 1	0.0000	720.00	960.00	Irrigation	SURF_PP	SE S22, W2 SE, W2 S23 T20N R66E	
17723	11/21/58	NW NE	10	18N	66E 1	0.0000 5	520.00 7	360.00	Irrigation	SURF_PP	NW, W2 NE, W2 SW, NE SW, NW SE S1, N2 NE S2 T18N R66E, E2 W2, W2 SE, NE NE S24, NE SW S25, SE S26, E2 SW, SE, E2 NE S35, NW, W2 SW S36 T19N R66E, SW NW S30 T19N	Comingled with 26266 & 26071
17906 5970	03/26/59	SW NE	32	17N	65E	0.5000	26.01	34.68	Irrigation & Domestic	SURF PE	NE NW, SE NW, SW NE S32 T17N R65E	
18043 5490	06/08/59	SW SW	31	12N	67E	0.0062	4.48	4.48	Stockwater	WELL OTH	SW SW S31 T12N R67E	
18044 5672	06/08/59	NW NW	6	11N	67E	0.0022	4.48	4.48	Stockwater	WELL OTH	NW NW S6 T11N R67E	
18045 5491	06/08/59	NW SE	35	11N	66E	0.0100	8.96	8.96	Stockwater	WELL OTH	NW SE S35 T11N R66E	
18183 5649	08/03/59	NE NW	25	14N	67E	0.5000	241.85	241.85	Mining & DOMESTIC	WELL PE	SW NW S24 T14N R67E	
18524 6138	01/18/60	NE NE	26	12N	67E	1.0026	0.00	0.00	Irrigation	WELL PE	NE NE S26 T12N R67E	SEE 30319
18525 6992	01/18/60	SE SW	24	12N	67E	2.1200	0.00	0.00	Irrigation	WELL PE	SE SW, SW SW S24 T12N R67E	SEE 30319
18827 7567	05/11/60	SE SE	12	12N	67E	3.0000	816.50 1	088.66	Irrigation	WELL_PE	N2 NE, SE NW, SE SW, SW SE S13, NW S24 T12N R67E	
18828 5492	05/11/60	NE NW	13	12N	67E	0.0062	4.48	4.48	Stockwater	WELL OTH	NE NW S13 T12N R67E	
18829 5493	05/11/60	SE NW	24	12N	67E	0.0062	4.48	4.48	Stockwater	WELL OTH	SE NW S24 T12N R67E	
18830 5494	05/11/60	NE NW	27	12N	67E	0.0062	4.48	4.48	Stockwater	WELL OTH	NE NW S27 T12N R67E	
18841 5673	05/13/60	NW SE	20	15N	67E	0.0111	8.96	8.96	Stockwater	WELL OTH	NW SE S20 T15N R67E	
18842 5674	05/13/60	NW NE	32	15N	67E	0.0125	8.96	8.96	Stockwater	WELL OTH	NW NE S32 T15N R67E	
18843 5675	05/13/60	SW NE	29	15N	67E	0.0125	8.96	8.96	Stockwater	WELL OTH	SW NE S29 T15N R67E	

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion				Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
19076	07/29/60	SW NE	10	18N	66E	7.0000 2	880.00 3	840.00	Irrigation	SURF_PP	SE SW, SW SE S1, NW, W2 NE, NW SE S12 T18N R66E, NW, SE S25, SE NE S26, NE, E2 SW, SE SE, NE SE S36 T19N R66E, W2 NW, SE NE S31 T19N R67E	Comingled with 11029, 25257, 25896
19435 7800	01/10/61	NW SW	24	20N	66E	0.0000	0.00	0.00	Irrigation	SURF_PE	SE SE S13 T20N R66E, NE NE, NW NE S19, NE NE, SE NE S24 T20N R67E	54.00 AC.FT. Annually for storage. No diversion rate given. SEE 19436
19436 7805	01/10/61	NE SE	13	20N	66E	0.0000	206.70	275.60	Irrigation	SURF_PE	SAME AS 19435	25.00 AC.FT. Annually for storage. No diversion rate given. Comingled with 19435
19524 5948	02/01/61	NW SE	33	15N	68E	0.2000	17.40	23.20	Irrigation & Domestic	SURF PE	S2 SW SW S34 T15N R68E	
19654 6449	03/09/61	SE SE	31	13N	67E	2.4500	431.87	575.73	Irrigation & Domestic	WELL_PE	SE SE S31, S2 SW, NW SW S32 T13N R67E	
19786 5434	04/28/61	NE NW	31	10N	66E	0.0100	11.20	11.20	Stockwater	WELL OTH	NE NW S31 T10N R66E	
20549	07/09/62	SE NE	34	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_PE	W2 NE, SE SW S27, NE, NE NW S34 T13N R67E	
20817 6777	10/29/62	NE NE	21	13N	67E	3.5000	480.00	640.00	Irrigation	WELL PE	N2 NE, SE NE, NE SE, S21 T13N R67E	
20895 7560	12/13/62	SW SE	25	19N	66E	3.0000	554.32	739.09	Irrigation & Domestic	SURF_PE	S2 SE S25, E2 NE, SW SE S36 T18N R66E, W2 NW, SE NW S31 T18N R67E	
21220 6505	01/01/83	SW NE	15	17N	66E	4.0000	575.82	767.76	Irrigation & Domestic	SURF_PE	SW NW, E2 NW, W2 NE, E2 SW, W2 SE S15 T17N R66E	
21687 6506	09/02/43	SW NE	15	17N	66E	3.5000	0.00	0.00	Irrigation	SURF_PE	W2, W2 NE, W2 SE S18, NW, N2 SW, NW NE S19 T17N R67E	SEE 21688
21688 6507	12/13/63	NW NW	23	17N	66E	4.0000 1	155.00 1	540.00	Irrigation	SURF_PE	SEE 21687	Comingled with 21687
21832 5817	02/21/64	SE SW	8	15N	68E	0.0012	0.89	0.89	Stockwater	SURF OTH	SE SW S8 T15N R68E	
22544 7566	04/16/65	NE NW	22	13N	67E	2.6800	0.00	0.00	Irrigation & Domestic	WELL PE	NW S22 T13N R67E	SEE 34727
22545 7571	04/16/65	NE SW	15	13N	67E	2.0000	480.00	640.00	Irrigation & Domestic	SURF PE	NW S22 T13N R67E	Comingled with 920 & 17163
24260 8030	12/04/67	SW NW	28	13N	68E	0.0078	5.64	5.64	Mining, Milling, & Domestic	SURF_PE	SW NW S28 T13N R68E	
24908	02/13/69	SE SE	34	20N	66E 1	0.0000 2	029.83 2	706.44	Irrigation	SURF_PP	NW NW, E2 NW, E2 S11, NW, W2 NE, N2 SW, SW SW S12, NW NW S13, N2 NE, NE NW, SW NE S14 T19N R66E	PORTION Comingled with 02305, 4041, 4042, 4043, 10766
25524 8666	04/03/70	SE SE	16	14N	67E	6.0000	301.56	301.56	Mining, Milling, & Domestic	WELL_PE	NW S22, NW S14, SE SE S16 T14N R67E	
25678 9294	02/28/66	SE NE	27	12N	68E	4.0000	472.68	630.24	Irrigation	SURF PE	SE SE S13, NE NE, SW NE, SE	SEE 34704
25680 9296	06/24/70	NE NE	24	12N	67E	1.5800	472.68	630.24	Irrigation	WELL PE	NE NE S24 T12N R67E	

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion				Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
25857	11/09/70	SE SE	3	18N	66E	3.0000	0.00	0.00	Irrigation	SURF_PP	SE SW, SW SE S1, NW, W2 NE, SE NE, N2 SE, SE SE S12 T18N R66E, SW NW, NW SW S7 T18N R67E	PORTION Comingled with 19076,
25896	12/21/70	SE SE	3	18N	66E	4.0000	0.00	0.00	Irrigation	SURF_PP	W2 NW, SW NW, S2 NE, NW SE, SE SE S12 T18N R66E, SW NW, NW SW S7 T18N R67E	SEE 19076
26071	04/22/71	NE SW	1	18N	66E	3.0000	0.00	0.00	Irrigation	SURF_PP	E2 NW, W2 NE, NW SE, NE SW S1 T18N R66E	SEE 17723
26072	04/22/71	SW SE	23	18N	66E 1	0.0000 3	000.00 4	000.00	Irrigation & Domestic	SURF_PP	W2 NW, SW S19, W2 W2, NE NW, SE SW S30, N2 N2 S31 T18N R67E, E2 SE S24, E2 E2, NW NE, W2 SE S25 T18N R66E	
26105	05/05/71	SW SE	23	19N	66E	7.5000 1	320.00 1	760.00	Irrigation & Domestic	SURF_PP	E2 NW, E2 SW, W2 SE S24, NE S25 T19N R66E, SW NW S30 T19N R67E	
26112	05/10/71	NE NE	26	19N	67E	8.0000 4	500.00 6	000.00	Irrigation	SURF_PP	NW, SE S25, E2 NE S26, E2, E2 SW S36 T19N R66E, SW SW S30, NW NW, S2 NW, SW, SW SE S31, N2 NW S6 T19N R67E	Comingled with 26263
26228 8363	07/26/71	NE SE	16	13N	67E	0.8910	0.00	0.00	Irrigation & Domestic	WELL_PE	NE SE, SE SE, NW SE, SW SE S16 T13N R67E	SEE 45648
26229	07/26/71	SE SW	15	13N	67E	1.5040	0.00	0.00	Irrigation & Domestic	WELL_PE	SE SW, SW SW S15 T13N R67E	SEE 34727
26263	08/17/71	SW SE	25	19N	66E	2.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	S2 SE S25, E2, E2 SW S36 T19N R66E, NW NW, S2 NW S31 T19N R67E	SEE 26112
26266	08/23/71	SE SE	3	18N	66E	3.2000	0.00	0.00	Irrigation	SURF_PP	W2 W2 S1 T18N R66E, E2 E2 S35, E2 NW S36, SW NE S25, E2 SE S26 T19N R66E	SEE 17723
26502 9300	01/25/72	SE NE	22	13N	67E	0.2700	55.11	73.48	Irrigation & Domestic	WELL_PE	SW NE, SE NW S22 T13N R67E	
26546 8365	04/16/65	NE NW	22	13N	67E	2.6800	0.00	0.00	Irrigation & Domestic	WELL_PE	SE SW, SW SW S15 T13N R67E	SEE 34727
26952 8366	09/07/72	NE NW	22	13N	67E	2.5000	0.00	0.00	Irrigation & Domestic	WELL_PE	NE SE, SE SE, NW SE, SW SE S16 T13N R67E	SEE 45648
27739 9772	09/07/73	NW NE	32	13N	68E	2.3000	0.00	0.00	Irrigation & Domestic	SURF_PE	N2 NE, NW S35 T13N R67E	SEE 27901
27740 9773	09/07/73	NE SE	18	13N	68E	3.2000	0.00	0.00	Irrigation & Domestic	SURF_PE	NW NE, NW S35 T13N R67E	SEE 27901
27741 9774	09/07/73	NW SW	20	13N	68E	0.5000	0.00	0.00	Irrigation & Domestic	SURF_PE	N2 NE, NW S35 T13N R67E	SEE 27901
27742 9775	09/07/73	NE SE	18	13N	68E	3.2000	0.00	0.00	Irrigation & Domestic	SURF_PE	N2 NE, NW S35 T13N R67E	SEE 27901
27743 9743	09/07/73	SW SW	4	11N	68E 8	7.0000 9	261.24 12	348.32	Irrigation & Domestic	SURF_PE	SE, E2 SW, SE NW, SW NE S35, W2 S36 T12N R67E, E2, SW, E2 NW, SW NW S2, W2, W2 E2 W1, SE SE S3, E2 NE, N2, SE, N2 SW S11, W2, SE, W2 NE, SE NE S12 T11N R67E	POU CONTINUED: SE NW, E2 NE, SW NE, N2 SW, W2 SE, NE SE S13, NE, SE NW, NW SW S24 T11N R67E. SEE 3865

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion				Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
27768 8979	09/19/73	SW NE	2	12N	67E	0.0278	20.12	20.12	Fish, Wildlife & Recreation	WELL_OTH	SW NE S2 T12N R67E	
27901 9776	11/15/73	NW SE	29	13N	68E	1.5000	617.43	823.24	Irrigation & Domestic	SURF_PE	N2 NE, NW S35 T13N R67E	Comingled with 27739-27742
27902 9744	11/15/73	NE SW	5	11N	68E	0.4600	49.50	66.00	Irrigation & Domestic	SURF_PE	NE SW, SE NW, SW NW S5, SE NE, SW NE S6 T11N R68E	
28653 10020	09/09/74	SE NE	34	13N	677 E	0.0270	0.22	0.29	Irrigation & Domestic	WELL_PE	SE NE S34 T13N R67E	
28790 9777	10/11/74	NE NE	35	13N	67E	0.2000	720.00	960.00	Irrigation & Domestic	SURF_PE	N2 NE, NW S35 T13N R67E	Comingled with 02851-02855, 2005, 6834
28818 9023	03/16/65	NW SE	25	18N	66E	4.8000	0.00	0.00	Irrigation & Domestic	SURF_PE	N2 SE, SE SE S25 T18N R66E, NW SE, SW NW S30 T18N R67E	SEE 01214
28841	10/29/74	NW SW	20	13N	68E	2.5000 1	650.00 2	200.00	Irrigation & Domestic	SURF_PP	NE S34, SW, S2 NW, NW NW S26, N2 NE, SW NE S27 T13N R67E	SUP. TO 31653, 28653, 29219-29221, 24899. COMINGLED WITH 28841-48, 28850-54, 28859, 28860, 28892, 28894, 29106-114
28842	10/29/74	NE NW	31	13N	68E	1.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28843	10/29/74	SW SE	30	13N	68E	1.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28846	10/29/74	SW SW	25	13N	67E	1.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28847	10/29/74	NW SW	25	13N	67E	0.5000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28848	10/29/74	NW NW	36	13N	67E	0.5000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28850	10/29/74	NW SE	30	13N	68E	1.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28851	10/29/74	SW SE	30	13N	68E	1.5000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28852	11/01/74	SW SE	30	13N	68E	1.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28853	11/01/74	SW SW	20	13N	68E	1.2500	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28854	11/01/74	NE SE	18	13N	68E	5.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28859	11/01/74	NE SE	18	13N	68E	5.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28860	11/01/74	NW NE	32	13N	68E	5.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28892	11/08/74	NE SE	32	13N	68E 1	0.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
28894	11/08/74	NE NE	8	13N	68E 1	0.0000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841
29106	12/27/74	SW SW	25	13N	67E	0.5000	0.00	0.00	Irrigation & Domestic	SURF_PP	SEE 28841	SEE 28841

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion				Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
29107	12/27/74	SW SW	25	13N	67E	0.5000	0.00	0.00	Irrigation & Domestic	SURF PP	SEE 28841	SEE 28841
29108	12/27/74	SW SW	25	13N	67E	0.5000	0.00	0.00	Irrigation & Domestic	SURF PP	SEE 28841	SEE 28841
29109	12/27/74	SW SW	25	13N	67E	0.5000	0.00	0.00	Irrigation & Domestic	SURF PP	SEE 28841	SEE 28841
29110	12/27/74	SW SW	25	13N	67E	0.5000	0.00	0.00	Irrigation & Domestic	SURF PE	SEE 28841	SEE 28841
29111	12/27/74	SE NE	29	13N	68E	2.5000	0.00	0.00	Irrigation & Domestic	SURF PP	SEE 28841	SEE 28841
29112	12/27/74	NW SE	29	13N	68E	1.0000	0.00	0.00	Irrigation & Domestic	SURF PP	SEE 28841	SEE 28841
29113	12/27/74	NW NW	28	13N	68E	1.0000	0.00	0.00	Irrigation & Domestic	SURF PP	SEE 28841	SEE 28841
29114	12/27/74	SE SE	26	13N	67E	0.5000	0.00	0.00	Irrigation & Domestic	SURF PP	SEE 28841	SEE 28841
29162 10107	01/24/75	NW NE	13	13N	67E	6.9000	297.51	396.68	Irrigation & Domestic	SURF_PE	SE, S2 SW S17, NW S22 T13N R67E	PORTIONS OF NW 22/13/67 COMINGLED WITH 17163, 15812, 22545
29219 8875	07/09/62	SW SE	26	13N	67E	2.3400 1	170.84 1	561.12	Irrigation & Domestic	WELL_PE	W2 NW, SE NW, SW S26, N2 NE, SW NE S27 T13N R67E	
29220 8876	07/09/62	SE NW	26	13N	67E	1.8900 1	025.97 1	367.96	Irrigation & Domestic	WELL_PE	W2 NW, SE NW, SW S26, N2 NE, SW NE S27 T13N R67E	
29221 8877	02/05/69	SE NW	26	13N	67E	1.4500	787.32 1	049.76	Irrigation & Domestic	WELL_PE	W2 NW, SE NW, SW S26, N2 NE, SW NE S27 T13N R67E	
29371 10328	05/08/75	SW SW	22	14N	67E	1.1100	801.07	801.07	Mining, Milling & Domestic	WELL_PE	SE S21, S2 S22, S2 S23, SW S24, N2 N2 N2 S26 T14N R67E	Comingled with 29567
29567 10329	08/08/75	SW SW	22	14N	67E	1.1100	0.00	0.00	Mining, Milling, & Domestic	WELL_PE	SE S21, S2 S22, S2 S23, SW S24, N2 N2 N2 S26 T14N R67E	SEE 29371
30319 10725	06/08/76	SW SE	24	12N	67E	1.3400	548.04	730.72	Irrigation	WELL_PE	SW NE, SE NE, NE SE, SW SE, NW SE, SE SW, SW SW S24, NW NW S25, NE NE S26 T12N R67E	Comingled with 18524 & 18525
31239 10334	03/25/77	NW SE	15	14N	67E	0.4900	176.91	176.91	Mining, Milling & Domestic	WELL_PE	E2 S10, S2 S11, SW S12, W2 S13, S14, E2 S15, T14N R67E	
31653	05/12/77	SE NW	26	13N	67E	2.7000	480.00	640.00	Irrigation & Domestic	WELL_PE	NE S34 T13N R67E	SEE APPLICATION TO CHANGE 51766
32030	06/13/77	NW NE	14	14N	66E 1	0.2000	480.00	640.00	Irrigation	WELL_DLE	S14 T14N R66E	
32031	06/13/77	NW NE	23	14N	66E 1	0.2000	480.00	640.00	Irrigation	WELL_DLE	S23 T14N R66E	
32032	06/13/77	NW NE	24	14N	66E 1	0.2000	480.00	640.00	Irrigation	WELL_DLE	S24 T14N R66E	

WATER BASIN 184
SPRING VALLEY
PERMITS AND APPLICATIONS

Application / Certificate		Point of Diversion				Diversion Rate	Consumption Allocated		Use	ACAD Block	Place of Use	Notes
Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
32035	06/13/77	NW NE	13	14N	66E 1	0.2000	480.00	640.00	Irrigation	WELL_DLE	S13 T14N R66E	
32036	06/13/77	NW NE	26	14N	66E 1	0.2000	480.00	640.00	Irrigation	WELL_DLE	S26 T14N R66E	
34704	12/07/77	NW SE	29	12N	68E	5.0000	847.30 1	129.73	Irrigation & Domestic	SURF_PP	SE SE S13, NE NE, S2 NE, N2 SE, SW SE, S2 SW S24, NW NW S25, NE NE S26 T12N R67E	157.56 AC. ALREADY COVERED BY 25678
34727 11889	12/12/77	NW NE	22	13N	67E	0.6600	603.59	804.79	Irrigation & Domestic	WELL_PE	SW SW, SE SW S15, NW NW NE NW, SW NW, SE NW, NW NE, SW NE S22 T13N R67E	Comingled with 26546, 26229, 22544. Supplemental to 29162 & 920
35439 9213	07/09/62	NE NE	34	13N	67E	1.3000	180.00	240.00	Irrigation & Domestic	WELL_PE	NE SE, SE SE S27 T13N R67E	
38888	08/23/79	NW SE	19	14N	68E 1	0.0000	9.50	9.50	Mining, Milling & Domestic	SURF_PP	NW SE, E2 NW S19, W2 S18 T14N R68E	
38972 11632	09/07/79	NW NE	35	13N	67E	1.7500	576.36	768.48	Irrigation & Domestic	WELL_PE	NW NW, SW NW, SE NW, NE SW, SW NE S35 T13N R67E	SUPPLEMENTAL TO 28790
39455 10441	11/01/79	SW SW	13	12N	67E	0.0200	16.80	16.80	Stockwater	WELL_OTH	W2 SW S13 T12N R67E	
39597	11/13/79	NE NW	19	15N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_PE	SEE 39598	SEE 39598
39598	11/13/79	SE NE	24	15N	66E	5.4000 3	300.00 4	400.00	Irrigation & Domestic	WELL_PE	E2 NW, NE, N2 SE, SE, SE, NE SW S24 T15N R66E, SE S18, W2 N2 NE, SE NE S19, N2 SW, SE NW, NW NE S20 T15N R67E	Application 54425 filed to change POD. Supplemental to 01216, 10703 (PORTION)
39816	11/23/79	NE NE	14	18N	66E	6.0000 2	640.00 3	520.00	Irrigation & Domestic	SURF_PE	SW, SW SE S12, W2, S2 SE, N2 SE S13, NE NE S14, N2 N2 S24 T18N R66E, SW SW S18, NW NW S19 T18N R67E	Supplemental to 01213 & 13457. Comingled with 39817
39817	11/23/79	SE SW	13	18N	66E	6.0000	0.00	0.00	Irrigation & Domestic	WELL_PE	SE SW, S2 SE, NE SE S13, N2 NE, NE NW S24 T18N R66E, SW SW S18, NW NW S19 T18N R67E	SEE 39816
39818	11/23/79	SE SE	24	18N	66E	6.0000 2	760.00 3	680.00	Irrigation & Domestic	WELL_PE	E2 SE S24, E2 E2 S25, NE NE S36 T18N R66E, SW NW, SW S19, W2 W2, NE NW, SW NE, SE SW S30, N2 N2 S31 T18N R67E	SUPPLMENTAL TO 01214 & 28818
41452	05/30/80	NE SE	18	14N	68E 1	0.0000	9.50	9.50	Mining, Milling &	SURF_PP	NE SE, S2 NE, SE NW, NE NW S18 T14N R68E	
42202	10/28/80	SE SW	8	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	S2 S8 T13N R67E	SEE 42203
42203	10/28/80	SE SE	8	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	SW S8 T13N R67E	Comingled with 42202

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42204	10/28/80	SW NW	17	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	N2 S17 S13N R67E	SEE 42205
42205	10/28/80	SW NE	17	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	N2 S17 T13N R67E	Comingled with 42204
42206	10/27/80	NE NE	7	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	NE S7, NW S8 T13N R67E	SEE 42207
42207	10/27/80	NE NW	8	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	NE S7, NW S8, T13N R67E	Comingled with 42206
42208	10/27/80	NE SE	5	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	SE S5, NE S8 T13N R67E	SEE 42209
42209	10/27/80	NE NE	8	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	NE NE S8 T13N R67E	Comingled with 42208
42210	10/27/80	SW SW	9	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	S2 S9 T13N R67E	SEE 42211
42211	10/27/80	SW SE	9	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	S2 S9 T13N R67E	Comingled with 42210
42212	10/27/80	NW NW	16	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	N2 S16 T13N R67E	SEE 42213
42213	10/27/80	NW NE	16	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	N2 S16 T13N R67E	Comingled with 42212
42214	10/27/80	NE NE	19	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	SE S18, NE S19 T13N R67E	SEE 42215
42215	10/27/80	SE SE	18	13N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	SE S18, NE S19, T13N R67E	Comingled with 42214
42232	10/28/80	NW SW	8	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	S2 S8 T10N R67E	SEE 42233
42233	10/28/80	NW SE	8	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	S2 S8 T10N R67E	Comingled with 42232
42236	10/28/80	NW NW	8	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	N2 S8 T10N R67E	SEE 42237
42237	10/28/80	NW NE	8	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	N2 S8 T10N R67E	Comingled with 42236
42240	10/28/80	SE SW	35	11N	66E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	W2 S35 T11N R66E	SEE 42241
42241	08/28/80	SE NW	35	11N	66E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S35 T11N R66E	Comingled with 42240
42242	10/28/80	SE NE	35	11N	66E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	NE NE S2 T10N R66E, NE, E2 SE, SW SE S35 T11N R66E	SEE 42243
42243	08/28/80	SE SE	35	11N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	NE NE S2 T10N R66E, NE, E2 SE, SW SE S35 T11N R66E	Comingled with 42242
42244	10/28/80	SE SW	24	11N	66E	5.4000	0.00	0.00	Irrigation	WELL_DLE	W2 S24 T11N R66E	SEE 42245

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42245	10/28/80	SE NW	24	11N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	W2 S24 T11N R66E	Comingled with 42244
42246	10/28/80	SE NW	25	11N	66E	5.4000	0.00	0.00	Irrigation	WELL_DLE	W2 S25 T11N R66E	SEE 42247
42247	08/28/80	SE SW	25	11N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	W2 S25 T11N R66E	Comingled with 42246
42248	10/28/80	NE SW	7	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	W2 S7 T10N R67E	SEE 42249
42249	08/28/80	NE NW	7	6N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S7 T10N R67E	Comingled with 42248
42250	10/28/80	NE NW	6	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	W2 S6 T10N R67E	SEE 42251
42251	10/28/80	NE SW	6	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	W2 S6 T10N R67E	Comingled with 42250
42252	10/28/80	SE NW	4	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	N2 S4 T10N R67E	SEE 42253
42253	08/28/80	SW NW	4	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	N2 S4 T10N R67E	Comingled with 42252
42258	10/28/80	SE NE	1	10N	66E	5.4000	0.00	0.00	Irrigation	WELL_DLE	E2 S1 T10N R66E	SEE 42259
42259	08/28/80	SE SE	1	10N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	E2 S1 T10N R65E	Comingled with 42258
42260	10/28/80	SE SW	36	11N	66E	5.4000	0.00	0.00	Irrigation	WELL_DLE	W2 S36 T11N R66E	SEE 42261
42261	10/28/80	SE NW	36	11N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	W2 S36 T11N R66E	Comingled with 42260
42262	10/28/80	SE NE	26	11N	66E	5.4000	0.00	0.00	Irrigation	WELL_DLE	E2 S26 T11N R66E	SEE 42263
42263	10/28/80	SE SE	26	11N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	E2 S26 T11N R66E	Comingled with 42262
42264	10/28/80	NE NE	36	11N	66E	5.4000	0.00	0.00	Irrigation	WELL_DLE	E2 S36 T11N R66E	SEE 42265
42265	10/28/80	NE SE	36	11N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	E2 S36 T11N R66E	Comingled with 42264
42266	10/28/80	NE NE	7	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	E2 S7 T10N R67E	SEE 42267
42267	08/28/80	NE SE	7	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	E2 S7 T10N R67E	Comingled with 42266
42268	10/28/80	SE NE	25	11N	66E	5.4000	0.00	0.00	Irrigation	WELL_DLE	E2 S25 T11N R66E	SEE 42269
42269	08/28/80	SE SE	25	11N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	E2 S25 T11N R66E	Comingled with 42268
42270	10/28/80	SE NE	24	11N	66E	5.4000	0.00	0.00	Irrigation	WELL_DLE	E2 S24 T11N R66E	SEE 42271

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42271	08/28/80	SE SE	24	11N	66E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	E2 S24 T11N R66E	Comingled with 42270
42272	10/28/80	NW SE	4	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	S2 S4 T10N R67E	SEE 42273
42273	08/28/80	NW SW	4	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	S2 S4 T10N R67E	Comingled with 42272
42274	08/28/80	SE SE	32	14N	67E	0.5400	0.00	0.00	Irrigation & Domestic	WELL_DLE	SE S32 T14N R67E, NE S5 T13N R67E	SEE 42275
42275	10/28/80	NE NE	5	13N	67E	0.5400	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	SE S32 T14N R67E, NE S5 T13N R67E	Comingled with 42274
42276	10/28/80	NE NW	5	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	W2 S5 T13N R67E	SEE 42277
42277	10/28/80	NE SW	5	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S5 T13N R67E	Comingled with 42276
42282	08/28/80	SW NE	33	14N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	N2 S33 T14N R67E	SEE 42283
42283	08/28/80	NW NW	33	14N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	N2 S33 T14N R67E	Comingled with 42282
42284	10/28/80	SW SW	6	12N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	W2 S6 T12N R67E	SEE 42285
42285	10/28/80	SW NW	6	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S6 T12N R67E	Comingled with 42284
42286	10/28/80	NW NE	7	12N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	NE, NW SE, SW SE S7, NW NW S8 T12N R67E	SEE 42287
42287	10/28/80	NW SE	7	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	NE, NW SE, SW SE S7, NW NW S8 T12N R67E	Comingled with 42286
42288	10/28/80	NW SW	7	12N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	W2 S7 T12N R67E	SEE 42289
42289	10/28/80	NW NW	7	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S7 T12N R67E	Comingled with 42288
42290	10/28/80	NE SE	5	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	S2 S5 T10N R67E	SEE 42291
42291	08/08/80	NE SW	5	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	S2 S5 T10N R67E	Comingled with 42290
42292	08/28/80	NE NW	5	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	N2 S5 T10N R67E	SEE 42293
42293	08/28/80	NE NE	5	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	N2 S5 T10N R67E	Comingled with 42292
42294	10/28/80	SW SE	6	12N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	E2 S6 T12N R67E	SEE 42295
42295	10/28/80	SW NE	6	12N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	E2 S6 T12N R67E	Comingled with 42294

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42296	10/28/80	SE NE	12	11N	66E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	E2 S12 T11N R66E	SEE 42297
42297	10/28/80	SE SE	12	11N	66E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S12 T11N R66E	Comingled with 42296
42298	10/28/80	SW NE	30	12N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	E2 S30 T12N R67E	SEE 42299
42299	10/28/80	SW SE	30	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S30 T12N R67E	Comingled with 42298
42300	10/28/80	SW SW	30	12N	67E	5.4000	0.00	0.00	Irrigation	WELL DLE	W2 S30 T12N R67E	SEE 42301
42301	10/28/80	SW NW	30	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S30 T12N R67E	Comingled with 42300
42302	10/28/80	SW NW	6	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	W2 S6 T11N R67E	SEE 42303
42303	10/28/80	SW SW	6	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S6 T11N R67E	Comingled with 42302
42306	10/28/80	NW NE	31	12N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	E2 S31 T12N R67E	SEE 42307
42307	10/28/80	NW SE	31	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S31 T12N R67E	Comingled with 42306
42308	10/28/80	NW SW	31	12N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	W2 S31 T12N R67E	SEE 42309
42309	10/28/80	NW NW	31	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S31 T12N R67E	Comingled with 42308
42310	10/28/80	SW NE	19	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	E2 S19 T11N R67E	SEE 42311
42311	10/28/80	SW SE	19	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S19 T11N R67E	Comingled with 42310
42314	10/28/80	NW NE	19	12N	67E	5.4000	0.00	0.00	Irrigation	WELL DLE	E2 S19 T12N R67E	SEE 42315
42315	10/28/80	NW SE	19	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S19 T12N R67E	Comingled with 42314
42316	10/28/80	SW SW	19	12N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	W2 S19 T12N R67E	SEE 42317
42317	10/28/80	NW NW	19	12N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S19 T12N R67E	COMINGLED WTIH 42316
42318	10/28/80	SE SE	13	11N	66E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	E2 S13 T11N R66E	SEE 42319
42319	10/28/80	SE NE	13	11N	66E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S13 T11N R66E	Comingled with 42318
42320	10/28/80	SE SW	13	11N	66E	5.4000	0.00	0.00	Irrigation & Domestic	WELL DLE	W2 S13 T11N R66E	SEE 42321
42321	10/28/80	SE NW	13	11N	66E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S13 T11N R66E	Comingled with 42320

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42322	10/28/80	SW NE	7	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	E2 S7 T11N R67E	SEE 42323
42323	10/28/80	SW SE	7	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S7 T11N R67E	Comingled with 42322
42324	10/28/80	SW SW	19	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	W2 S19 T11N R67E	SEE 42325
42325	10/28/80	SW NW	19	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S19 T11N R67E	Comingled with 42324
42326	10/28/80	NW NW	7	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	W2 S7 T11N R67E	SEE 42327
42327	10/28/80	NE SW	7	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S7 T11N R67E	Comingled with 42326
42328	10/28/80	SW NE	18	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	E2 S18 T11N R67E	SEE 42329
42329	10/28/80	SW SE	18	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S18 T11N R67E	Comingled with 42328
42330	10/28/80	SW NW	18	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	W2 S18 T11N R67E	SEE 42331
42331	08/28/80	NW SW	18	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S18 T11N R67E	Comingled with 42330
42711	10/24/80	NE NW	5	6N	68E	1.5000	11.20	11.20	Stockwater &	SURF_OTH	ALONG THE CHANNEL THRU S4 & 5 T6N R68E	
42776	11/04/80	NE NE	6	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	E2 S6 T13N R67E	SEE 42777
42777	11/04/80	NE SE	6	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	E2 S6 T13N R67E	Comingled with 42776
43033	01/02/81	NE NE	21	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	N2 S21 T10N R67E	
43036	01/02/81	NE NW	17	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	N2 S17 T10N R67E	SEE 43037
43037	01/02/81	NE NE	17	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	N2 S17 T10N R67E	Comingled with 43036
43038	01/02/81	NE SW	16	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	S2 S16 T10N R67E	SEE 43039
43039	01/02/81	NE NE	16	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	S2 S16 T10N R67E	Comingled with 43038
43057	01/06/81	NE NE	18	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	N2 S18 T10N R67E	SEE 43058
43058	01/06/81	NE NW	18	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	N2 S18 T10N R67E	Comingled with 43057
43059	01/06/81	NE SW	18	10N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	S2 S18 T10N R67E	SEE 43060

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43060	01/06/81	NE SE	18	10N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	S2 S18 T10N R67E	Comingled with 43059
43439	03/30/81	NE NE	14	14N	66E	6.0000	0.00	0.00	Industrial	WELL_PP	S1,3, 11 THRU 14, N2 S23, N2 S24 T14N R66E	No duty given
44348 10856	03/30/81	NW SE	10	45N	38E	0.0062	11.20	11.20	Stockwater	WELL_OTH	SW NW S16 T45N R38E	
45175	12/31/81	SE SW	16	14N	67E	5.5600	960.00 1	280.00	Irrigation	WELL_DLE	NW, SW S16 T14N R67E	
45287 11017	01/13/76	NE SW	12	12N	67E	1.3500	234.60	312.80	Irrigation	WELL_PE	SW NW, NE SW S12 T12N R67E	
45311	02/10/82	NE NE	18	13N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	SE S7, NE S18 T13N R67E	SEE 45312
45312	02/10/82	SE SE	7	13N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	SEE 45311	Comingled with 45311
45496 11965	04/02/82	SE NW	23	8N	68E	0.1203	86.24	86.24	Stockwater	WELL_OTH	SE NW S23 T8N R68E	
45636	05/07/82	NE SE	32	13N	68E	5.0000	0.00	0.00	Irrigation	SURF_PP	S2 S27 & S28 T14N R67E	SEE 45876
45637	05/07/82	NE NE	8	12N	68E	5.0000	0.00	0.00	Irrigation	SURF_PP	S2 S27 & S28 T14N R68E	SEEKS 100 AC.FT. Storage for irrigation of 640 acres. See 45876
45648	05/10/82	NW SE	16	13N	67E	4.5000	810.00 1	080.00	Irrigation & Domestic	WELL_PE	NW SW, N2 S2 SW S15, N2 S2 S2 S16 T13N R67E	Comingled with 26952 & 26228.
45675	05/17/82	SE SE	15	18N	66E	8.0000	0.00	0.00	Hydro Electric Power	SURF_PP	SW NW S13, SE NE S14 T18N R66E	NON-CONSUMPTIVE USE
45676	05/17/82	SE SW	28	20N	66E 1	5.0000	0.00	0.00	Hydro Electric Power	SURF_PP	E2 SW S22 T20N R66E	NON-CONSUMPTIVE USE
45677	05/17/82	SE NW	16	20N	66E 2	0.0000	0.00	0.00	Hydro Electric Power	SURF_PP	SEE 45676	NON-CONSUMPTIVE USE
45679	05/17/82	SW NE	10	18N	66E 4	0.0000	0.00	0.00	Hydro Electric Power	SURF_PP	W2 NE S2 T18N R66E	NON-CONSUMPTIVE USE
45681	05/19/82	SW SW	35	18N	66E 4	0.0000	0.00	0.00	Hydro Electric Power	SURF_PP	N2 SE S1 T17N R66E	NON-CONSUMPTIVE USE
45682	05/19/82	SE SW	28	20N	66E 1	5.0000	0.00	0.00	Hydro Electric Power	SURF_PP	NW NW S11 T19N R66E	NON-CONSUMPTIVE USE
45683	05/19/82	NE NE	28	19N	66E 3	0.0000	0.00	0.00	Hydro Electric Power	SURF_PP	NE NE S26 T19N R66E	NON-CONSUMPTIVE USE

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45684	05/19/82	SE SW	9	19N	66E 1	0.0000	0.00	0.00	Hydro Electric Power	SURF_PP	NE NW S14 T19N R66E	NON-CONSUMPTIVE USE
45685	05/19/82	NE NE	27	18N	66E 2	0.0000	0.00	0.00	Hydro Electric Power	SURF_PP	SW SW S24 T18N R66E	NON-CONSUMPTIVE USE
45748	06/03/82	NW NW	17	16N	68E 1	0.0000	0.00	0.00	Hydro Electric Power	SURF_PP	N2 NE S2 T16N R67E	NON-CONSUMPTIVE USE
45749	06/03/82	NE NW	1	16N	66E	6.0000	0.00	0.00	Hydro Electric Power	SURF_PP	NE NW, SE SW S6 T16N R67E	NON-CONSUMPTIVE USE
45750	06/03/82	NW NE	34	16N	66E 5	0.0000	0.00	0.00	Hydro Electric Power	SURF_PP	S3 SE S13 T16N R66E	NON-CONSUMPTIVE USE
45798	06/16/82	SW NE	36	17N	67E	1.0000 26	063.00 26	063.00	Industrial	WELL_PP	SECS 13,24,25 T13N R66E, SECS 17 - 19, N2, N2 S2, SE SE, SW SW S20, W2 W2 S29, S30 T13N R67E	APP. 45798-45831, 45833 N.T.E. 26063.--AC.FT./YR
45799	06/16/82	NE NW	1	16N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45800	06/16/82	SE SE	2	16N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45801	06/16/82	NW SE	11	16N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45802	06/16/82	NE SW	14	16N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45803	06/16/82	NW SW	23	16N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45804	06/16/82	SE SE	34	16N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45805	06/16/82	NE SE	12	15N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45806	06/16/82	SW SE	11	15N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45807	06/16/82	SW SE	14	15N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45808	06/16/82	NE NE	35	16N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45809	06/16/82	SE SE	35	16N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45810	06/16/82	SE SE	35	15N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45811	06/16/82	SE SE	2	14N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45812	06/16/82	SE SE	11	14N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45813	06/16/82	SE SE	14	14N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45814	06/16/82	SE SW	23	14N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798

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Permit/Proof	Date of Priority	1/4/1/4	Sec.	Township Range			AcFt/Yr	Duty AcFt/Yr				
45815	06/16/82	SW SW	26	14N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45816	06/16/82	SE SW	1	15N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45817	06/16/82	SE SW	12	15N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45818	06/16/82	NW SW	13	15N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45819	06/16/82	SE NE	23	15N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45820	06/16/82	NE SE	26	14N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45821	06/16/82	NW NE	25	15N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45822	06/16/82	SE SE	34	14N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45823	06/16/82	NW NW	11	13N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45824	06/16/82	SE SW	11	13N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45825	06/16/82	SW SE	14	13N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45826	06/16/82	SW SW	24	13N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45827	06/16/82	SW SW	25	13N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45828	06/16/82	NW SW	12	12N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45829	06/16/82	SW NW	13	12N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45830	06/16/82	NW NE	24	12N	66E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45831	06/16/82	NE NW	4	13N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45832		NE NE	9	13N	67E	1.0000	0.00	0.00		WELL_PP		No record on file. Information taken from Township & Range card
45833	06/16/82	SE SE	9	13N	67E	1.0000	0.00	0.00	Industrial	WELL_PP	SEE 45798	SEE 45798
45876	06/25/82	SW SE	26	13N	67E 1	0.0000 1	920.00 2	560.00	Irrigation	SURF_PP	S2 S27 AND S28 T14N R67E	Comingled with 45636 & 45637
46097	08/27/82	NE NW	7	14N	67E	2.7000	480.00	640.00	Irrigation & Domestic	WELL_DLE	SW S7 T14N R67E	
46098	08/27/82	NW NE	7	14N	67E	2.7000	480.00	640.00	Irrigation & Domestic	WELL_DLE	NW S7 T14N R67E	
46099	10/27/82	NW NW	23	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S23 T11N R67E	Comingled with 46101
46100	10/27/82	SE SE	23	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	E2 S23 T11N R67E	SEE 46102
46101	10/27/82	SW SW	23	11N	67E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_DLE	W2 S23 T11N R67E	SEE 46099

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46102	10/27/82	NE NE	23	11N	67E	5.4000	960.00 1	280.00	Irrigation & Domestic	WELL_DLE	W2 S23 T11N R67E	Comingled with 46100
46275	10/27/82	NE NW	27	13N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	NW SE, NE, NE SW, SW SE, SW SE S27 T13N R67E	SEE 46276
46276	10/27/82	NW SE	27	13N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	NW, SE NE, NE SW, NW SE, SW SE S27 T13N R67E	Comingled with 46275, SEE 48276
46502	01/04/83	NE SW	29	13N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	E2 NW, NE SW, NW SE, NE S29 T13N R67E	
46503	01/04/83	SW SW	29	13N	67E	5.4000	960.00 1	280.00	Irrigation	WELL_DLE	S2 SW, S2 SE, NE SE S29, NE NW, N2 NE S32 T13N R67E	
46790	04/05/83	NE NE	7	14N	68E	1.0000	134.02	134.02	Mining, Milling, & Domestic	SURF_PE	NE S7, W2 NW S8 T14N R68E	
46923	05/17/83	NE SW	29	14N	68E	1.0000	0.00	0.00	Mining & Domestic	SURF_PP	SEC 29 THRU 32 T14N R68E, S23,25,26 & 35 T14N R67E	No duty given
46924	05/17/83	NE SE	30	14N	68E	1.0000	0.00	0.00	Mining & Domestic	SURF_PP	SEE 46923	No duty given
46973	06/03/83	LOT 37	7	14N	68E	0.5000	360.92	360.92	Mining, Milling & Domestic	SURF_PE	W2 SECS 1,2,3, 10-15, N2 S22, N2 S23, N2 S24 T14N R67E, S7 & S18 T14N R68E	
46975	06/03/83	LOT 37	7	14N	68E	0.5000	360.92	360.92	Mining, Milling, & Domestic	SURF_PE	SEE 46973	
46978	06/03/83	NE SE	18	14N	68E	0.5000	360.92	360.92	Mining, Milling & Domestic	SURF_PE	SEE 46973	
47278	09/29/83	SE NW	10	14N	68E	3.0000	264.38	264.38	Mining & Milling	WELL_PE	S2 S32, S2 S33, S34 T15N R68E, S2, S3, N2 S4, NW S10 T14N R68E	
47352	10/24/83	NW NE	25	14N	67E	0.5000	362.13	362.13	Mining & Milling	SURF_PE	SE NW, W2, NE, SE NE, N2 SE S23, S2 NW, SW NE, NW SE S24 T14N R67E	
48276	10/06/84	NW SE	35	13N	67E	5.4000	0.00	0.00	Irrigation	WELL_DLE	SW NE, NW SE, NE SW, NW SW S35 T13N R67E	APPLICATION TO CHANGE 46276
48724	01/17/85	NW NE	5	10N	68E	0.1800	13.44	13.44	Stockwater	SURF_OTH	W2 NE, SE NW, E2 SW S15, E2 NW, SW S22, W2 W2 S27, E2 NE S33, W2 NW S34 T10N R68E	
50772	04/02/87	NW NW	12	13N	67E	6.5000	990.00 1	320.00	Irrigation & Domestic	SURF_PE	NW SW, S2 SW S15, N2 SE, S2 SE, NE SW, SE SW S16 T13N R67E	SEE 45648
51766	01/14/88	SE NW	26	13N	67E	2.7000	0.00	0.00	Irrigation & Domestic	WELL_PP	NE E2 SE S27, W2 NW, SE NW, SW S26, NE S34 T13N R67E	SEE 28841 & 31653
53911	10/03/89	NW SE	15	14N	67E	3.0000	184.13	184.13	Mining	WELL_PP	E2 S15, E2 S11, SW S12, W2 S13, S14 T14N R67E	
54003	10/17/89	NW NE	20	8N	68E	6.0000	0.00	0.00	Municipal	WELL_LVP		

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54004	10/17/89	NE SE	25	9N	67E	6.0000	0.00	0.00	Municipal	WELL LVP		
54005	10/17/89	NE NE	14	9N	67E	6.0000	0.00	0.00	Municipal	WELL LVP		
54006	10/17/89	SE SE	22	10N	67E	6.0000	0.00	0.00	Municipal	WELL LVP		
54007	10/17/89	SE NW	34	11N	66E	6.0000	0.00	0.00	Municipal	WELL LVP		
54008	10/17/89	SW SW	1	11N	66E	6.0000	0.00	0.00	Municipal	WELL LVP		
54009	01/17/89	NW NE	36	13N	66E	6.0000	0.00	0.00	Municipal	WELL LVP		
54010	10/17/89	SE SE	25	14N	66E	0.0000	0.00	0.00	Municipal	WELL LVP		
54011	10/17/89	NE SE	14	14N	66E	6.0000	0.00	0.00	Municipal	WELL LVP		
54012	10/17/89	SE NE	16	14N	67E	6.0000	0.00	0.00	Municipal	WELL LVP		
54013	10/17/89	SW SW	25	15N	66E	6.0000	0.00	0.00	Municipal	WELL LVP		
54014	10/17/89	SW SW	15	15N	67E	6.0000	0.00	0.00	Municipal	WELL LVP		
54015	10/17/89	SW NW	14	15N	67E	6.0000	0.00	0.00	Municipal	WELL LVP		
54016	10/17/89	NE SW	7	15N	67E	6.0000	0.00	0.00	Municipal	WELL LVP		
54017	10/17/89	NW SE	25	16N	66E	6.0000	0.00	0.00	Municipal	WELL LVP		
54018	10/17/89	SE NE	24	16N	66E	6.0000	0.00	0.00	Municipal	WELL LVP		
54019	10/17/89	SW NE	12	12N	68E[1]	0.0000	0.00	0.00	Municipal	WELL_LVP		
54020	10/17/89	SE SE	22	14N	67E[1]	0.0000	0.00	0.00	Municipal	WELL_LVP		
54021	10/17/89	SW NE	33	16N	66E[1]	0.0000	0.00	0.00	Municipal	WELL_LVP		
54204	12/01/89	NW NE	19	16N	67E	3.0000	0.00	0.00	Irrigation & Domestic	WELL_PP	E2 N2, NE SE S13 T16N R66E, S18, NE NW, SW NE, N2 NE S19 T16N R67E	SEE 54205
54205	12/01/89	SE SW	13	16N	66E	3.0000[2]	760.00[3]	680.00	Irrigation & Domestic	WELL_PP	SEE 54205	Comingled with 54204
54425	02/12/90	NE SW	24	15N	66E	5.4000	0.00	0.00	Irrigation & Domestic	WELL_PP	E2 NW, NE, N2 SE, N2 SE SE, NE SW S24 T15N R66E, SE S18, W2	SEE 39598

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APPENDIX C

APPENDIX C

STEADY STATE MODEL SENSITIVITY

A steady state simulation is a simulation in which recharge and pumping rates are held constant with no change in ground-water storage, so that model-predicted ground-water levels are representative of long-term stabilized ground-water conditions in the natural environment. Therefore, the steady-state simulation will agree with historic measured water levels if appropriate hydraulic parameters are used in the simulation model. Model hydraulic parameters are adjusted until the steady-state simulation closely approximates the historical ground-water levels. The adjusted parameters must be reasonable. Both the number of differing and discernable values and the range of these values must be consistent with the occurrence of strata which possess these properties and the estimated range, or variabilities of these properties, based on field observations and testing of these properties of the strata.

The primary purpose of the steady-state simulations is to calibrate the model. Transmissivity can be calibrated if sufficient water level elevations are known. This was done as a part of the present study. Calibration of Spring Valley ground-water model was accomplished using several constraints that were identified in the "Model Development" section of this report.

The calibration of the model was carried out so that the total quantity of ground-water flow was matched, as closely as possible, the estimates made in Rush and Kazmi (1965) and Harrill et al. (1988). The calculation of the recharge to the Spring Valley model resulted in a value equal to that calculated by Rush and Kazmi (1965) although they rounded the 72,000 acre-feet to 75,000 acre-feet per year. The transmissivities of the modelled units, the leakance between these units, and the conductances used in the general head boundary conditions that connect the modelled area to adjacent hydrographic basins were constrained with the intent to replicate the quantities of water reported in Rush and Kazmi (1965) and Harrill et al. (1988), while at the same time matching the actual water levels.

As stated above, the calibration of the model was also carried out so that observed ground-water levels and the gradient or changes between these levels within the modelled area were matched as well as possible with little subjective changes in the model parameters. Fifty-eight wells were used in Spring Valley for model calibration. With the number of wells and the areal coverage, matching the actual water levels, while generally preserving the overall budget volumes became the most significant constraint.

The ground-water levels in the wells shown in Table 1 and Table 11 of the report were used during the calibration. The ground-water levels, resulting from the calibration are shown in Figures 21 and 22, together with the observed ground-water levels.

Model Parameter Sensitivities

Sensitivity simulations were done to determine the effects of each parameter on the ground-water levels and flows and are reported in the attached Table 1. These parameters are the transmissivities (L1T1, L2T1, etc.) and leakances (TK1, TK2). The sensitivities were performed about the calibrated values of the model and represent the linearized change in water level elevation that would occur with a change in the specific parameter value. The model rows and columns for the observation wells are listed in the attached Table 1 as well as designated in Table 11 in the report with each individual well for correlation. The sensitivities represent the estimated change in ground-water level at the wells with a 100 percent increase in the calibrated values that have been previously reported in the "Model Development" section of this report. The results of these sensitivity simulations are discussed briefly.

Analyses of the sensitivity simulations resulted in several general observations regarding the estimated model properties. All of the wells located in Spring Valley are in the alluvium. The transmissivities of the alluvial, valley-fill aquifer and the lower carbonate aquifer produced the most significant changes in ground-water levels and flows over the modelled area. The transmissivity of the alluvial aquifer in Spring Valley fell within the range of transmissivities resulting from aquifer tests preformed as part of the Los Angeles Water and Power's study (Leeds, Hill, and Jewett, Inc. (1983)) of the hydrology of Spring Valley. The high lower layer carbonate aquifer transmissivities were necessary to move the water from the recharge areas to discharge (ET and drains) areas and match existing water levels. Changes in the upper layer volcanic and clastic aquifers and upper layer carbonate aquifer transmissivities and the leakances between the layers did not produce significant changes in the majority of the ground-water levels.

Table 1.--Wells used in calibration.

							RESULTS OF SENSITIVITY RUNS							
Well ID No.	Location	Row	Col	Actual	Simu-lated	▲	T1L1 3500	T2L1 1500	T3L1 500	T4L1 250	T5L1 50	TK $1.9\text{x}10^{-5}$	T1L2 2000	T2L2 500
1	8N-68E 23BAC[1]	103	22	5762	5824	-63	-11	0	0	0	0	-2	-20	0
2	10N-67E 7BA	90	11	5716	5780	-64	1	-1	0	1	0	-0	-1	0
3	11N-66E 24BDA	86	10	5757	5780	-23	0	-2	0	0	-1	-0	-1	-2
4	11N-66E 1AAB	83	11	5788	5777	11	0	1	0	0	0	0	-1	-2
5	11N-66E 23AB	86	10	5793	5780	13	0	-2	0	0	-1	-0	-1	-2
6	11N-66E 35DBA	88	10	5787	5775	7	2	-1	0	0	-1	-0	-1	-2
7	9N-68E 30AAA	99	18	5764	5808	-44	-6	-1	0	0	0	-1	-15	0
8	10N-68E 31CD	95	17	5800	5800	0	-3	-1	0	0	0	-1	-10	0
9	11N-68E 19CDC	86	18	5825	5808	17	-6	-3	0	1	0	-0	-8	0
10	11N-68E 31CDC	88	17	5780	5796	-16	-3	-3	0	0	0	-0	-6	0
11	10N-67E 16AAB	91	14	5785	5788	-3	-1	-1	0	0	0	-1	-4	-1
12	10N-67E 22AA	92	15	5854	5794	60	-3	-1	0	0	0	-1	-7	-1
13	10N-67E 23ACB	92	15	5772	5794	-22	-3	-1	0	0	0	-1	-7	-1
14	10N-67E 26BB	93	15	5825	5796	28	-3	-1	1	0	0	-1	-7	0
15	11N-67E 13B	85	16	5793	5790	3	0	0	0	0	0	0	-1	0
16	17N-67E 28A	51	13	5538	5548	-10	0	3	0	1	0	0	2	0
17	20N-67E 9BA[1]	30	13	5598	5751	-154	-8	-1	0	0	0	0	-5	0
18	16N-67E 18A	55	11	5569	5607	-38	-3	-9	0	3	0	0	-3	-1
19	18N-66E 1B	41	10	5580	5579	1	1	-1	0	0	0	0	0	0
20	17N-68E 7AB	47	17	5540	5552	-12	3	-1	0	1	0	-0	5	0
21	16N-67E 3AAA	53	15	5581	5583	-2	2	-8	0	0	0	-1	2	0
22	16N-67E 27DAD	57	15	5592	5609	-17	0	-6	0	0	0	-1	2	2
23	18N-67E 1CCA	41	16	5552	5569	-17	5	-4	0	1	0	-0	8	-1
24	19N-67E 13AAA	37	16	5574	5614	-40	14	-5	1	1	0	-0	5	0
25	20N-67E 26ABB	33	15	5591	5685	-94	0	-1	0	0	0	-0	0	0
26	12N-67E 8A	78	12	5730	5767	-37	-2	1	0	-1	0	0	-2	0
27	13N-67E 8ACA	72	12	5756	5769	-13	-11	-1	0	-1	0	-0	-9	1
28	13N-67E 31DDC	77	11	5763	5798	-35	-6	0	0	-2	-3	-1	-7	-1
29	15N-66E 13D	61	10	5746	5711	34	0	-2	1	-4	-6	-2	-20	1
30	16N-66E 36DBA	58	11	5644	5620	24	-2	-5	0	-1	2	-0	-3	3
31	19N-66E 14AB	37	9	5657	5658	-1	-6	-4	0	2	0	0	-1	0
32	13N-67E 17DBA	73	12	5778	5773	5	-10	-1	0	-1	1	-0	-8	2
33	13N-67E 18DCB	73	11	5799	5803	-5	-9	0	1	-2	-3	-1	-16	-3
34	14N-66E 24AAB	68	10	5815	5814	0	-5	-1	1	-4	-7	-2	-26	-20
35	14N-66E 24BDD	68	10	5804	5814	-11	-5	-1	1	-4	-7	-2	-26	-20
36	14N-66E 25BAD	69	10	5819	5823	-4	-6	-1	0	-5	-7	-2	-27	-21
37	15N-66E 25DAD	63	10	5809	5729	79	-1	-1	1	-3	-6	-2	-21	0
38	12N-67E 27B	81	14	5737	5782	-45	-1	0	0	0	0	-0	-1	-1

Table 1.--Wells used in calibration (Continued).

							RESULTS OF SENSITIVITY RUNS							
Well ID No.	Location	Row	Col	Actual	Simu-lated	Δ	T1L1 3500	T2L1 1500	T3L1 500	T4L1 250	T5L1 50	TK 1.9x10^{-5}	T1L2 2000	T2L2 500
39	14N-67E 22CCC	68	14	5733	5727	6	-8	-1	0	0	0	-0	-6	2
40	15N-67E 2DAC	59	15	5616	5621	-3	2	-5	0	0	0	-1	2	2
41	15N-67E 26CA	63	15	5645	5658	-13	0	-4	0	-1	0	-1	-1	2
42	12N-67E 2ACB	77	15	5801	5780	21	-4	-1	0	0	0	0	-6	0
43	12N-67E 12CAA	78	16	5851	5796	55	-7	-3	0	0	0	-0	-8	1
44	12N-67E 13A	79	16	5892	5795	97	-5	-3	0	0	0	-0	-7	0
45	12N-67E 24BBB	79	16	5791	5795	-4	-5	-3	0	0	0	-0	-7	0
46	12N-67E 24CDD	80	16	5824	5796	28	-4	-3	0	0	0	-0	-6	0
47	13N-67E 15CBB	73	14	5776	5779	-3	-12	-1	0	-1	0	-0	-9	2
48	13N-67E 15CDA1	73	14	5777	5779	-2	-12	-1	0	-1	0	-0	-9	2
49	13N-67E 22ADB	74	14	5788	5779	9	-9	0	0	0	0	-0	-8	1
50	13N-67E 26BAD	75	15	5787	5787	0	-11	-1	0	-1	0	-0	-9	0
51	13N-67E 33DDA	76	14	5769	5773	-4	-3	0	0	0	0	0	-4	1
52	13N-67E 34AAA	76	15	5808	5783	25	-6	-1	0	0	0	-0	-7	1
53	13N-66E 25A	75	10	5936	5833	103	-8	-1	0	-4	-5	-1	-19	-13
54	21N-66E 4B	22	8	6059	6068	-9	-75	0	4	-12	0	-0	-94	0
55	23N-66E 19A	13	6	6380	6412	-33	-43	0	-14	-9	1	-0	-229	1
56	23N-66E 31AB	15	6	6380	6367	12	-54	0	-16	-13	1	-1	-215	1
57	23N-65E 10D	12	3	6620	6452	168	-56	0	-30	-14	0	-1	-252	0
58	23N-66E 7C	12	6	6464	6445	19	-53	0	-25	-14	0	-1	-249	0